THE
ENGINEERING REVIEW.

Edited by

C. EDGAR ALLEN.

Vol. XVIII. FEBRUARY, 1908. No. 2.

The Locomotive as a Field for the Inventor.

By CHAS. S. LAKE, A.M.I.Mech.E., Member Society of Arts.

EVER since the day upon which George Stephenson demonstrated, by the performance of his engine, the "Rocket," at the Rainhill trials of 1829, that the steam locomotive represented a practical means of working railway traffic, inventors have been busily devoting their time and energies to the task of improving that type of machine.

How far the inventor may claim credit for advancing the locomotive to its present state of efficiency, or in what measure the results are due to consecutive proportional developments based upon a fixed principle, it would be difficult to judge. We may be content with the knowledge that both have played an all-important part in the process of evolution which has culminated in the production of the locomotive as we find it at the present day. To those who are, if only to an ordinary extent, interested in the subject of locomotive design and construction, research among the Patent Office records relating to this branch of engineering must prove an absorbing occupation, for therein lies the opportunity of forming acquaintanceship with a branch of locomotive history as yet collectively unwritten. Careful study reveals facts of more than usual interest, and it comes as a surprise to learn that some of the methods and devices now associated only with the most recent practice were, in a somewhat different form, it is true, but still embodying the same idea, anticipated in some cases upwards of fifty years ago. It also becomes apparent that among the earlier inventors many there were who evidently foresaw what the probable line of locomotive development would be, and that successive enlargements of the demands for greater tractive power would render compulsory the taking of measures at that time altogether uncalled for, and, moreover, impossible of application.

On the other hand, there is abundant

evidence to show that a not inconsiderable proportion of the inventors who essayed the task of improving the locomotive could have been but barely acquainted with the principles upon which such engines are built and operated, otherwise they surely would never have wasted their time and money in projecting ideas of such impracticability as those disclosed in the patent specifications covering their inventions.

At an early stage the desirability of having at hand a means of increasing the power of locomotives when ascending inclines, would seem to have commended itself to inventors, for we find numerous patents granted in respect of devices aiming at the accomplishment of this purpose.

In 1867 a plan was patented whereby the locomotive was to "wind itself along" by means of a barrel or drum carried by itself and driven off an independent crank shaft, which shaft received direct motion from a pair of inside cylinders and transmitted it again through gearing to the driving wheels on the rails.

The railway was to be provided with a rope passing from end to end of it, and the drum on the locomotive was intended to wind the rope in front of it and lay it out behind. In the drawing, Fig. 1, the engine is shown mounted upon four wheels of equal diameter and the drum is carried on a special shaft midway between the frames. The boiler has two separate barrels arranged alongside one another, and the drum revolves between them.

To use the exact words of the inventors in their patent specification:

"The drum may conveniently have holding instruments upon it to clip firmly a rope passing only partly around it, and in this case the rope is first taken around a guide pulley on the axle of the leading wheels, then around the clip drum, and again over the guide pulley which lays the rope on the line behind the engine; or a plain winding drum may be

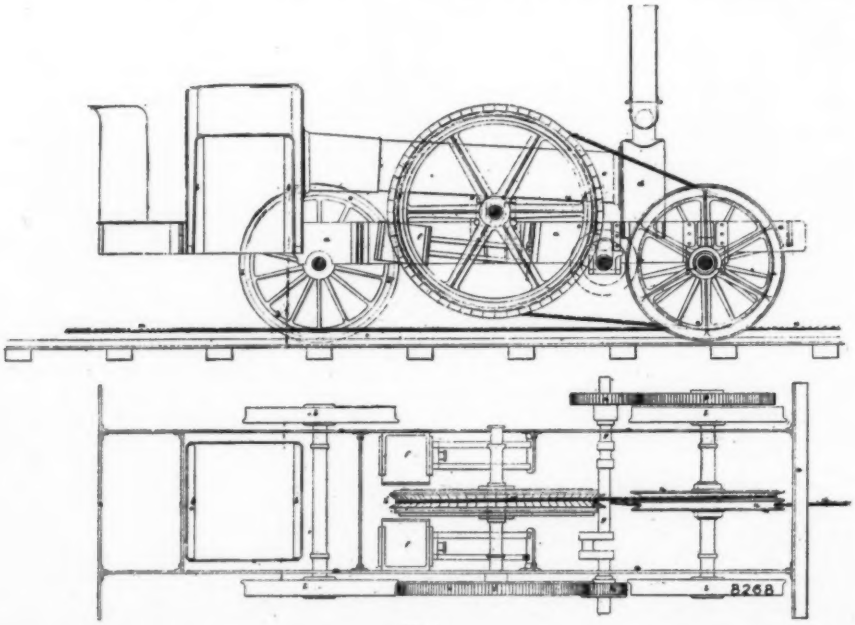


FIG. 1.

employed with the rope passing several times around it to obtain sufficient hold. The engines are arranged to drive a crank shaft under the boiler, and a pinion on the shaft drives a spur wheel on the axis of the drum. In order that the engine may be able to move independently of the rope when required to do so, another pinion is mounted on the crank shaft, which can be thrown into gear with a spur wheel on the axle of one or other pair of carrying wheels. The line of railway is provided with suitable supports for the rope between the rails, which both keep it off the ground and also keep it in place between the rails as is requisite on curves. The rope is firmly attached at each end of the section of line to which it is applied, and at junctions and sidings means are provided for separating it and connecting up with one or other of the ropes of the several diverging lines; also means are provided for securing the rope firmly whilst it is disconnected."

It is impossible to say whether this invention ever took practical shape or not; it was designed for application to locomotives more or less permanently engaged in working on inclines, and was therefore hardly applicable for ordinary purposes.

Innumerable measures for temporarily increasing locomotive tractive power have been put forward at various times. Some thirty years ago an Italian inventor conceived the idea of providing locomotives with two or more pairs of driving wheels of different diameters mounted upon the same axle, the idea being to employ the larger wheels for running at the higher speeds on the level and down hill, and the smaller ones for ascending gradients. The permanent way of the railway was to consist, wherever inclines occurred, of two tracks, one inside the other, the difference in gauge being of course necessary in order to secure clearance for the wheels not in use. The four driving wheels on the common axle were to take motion from the same cylinders, connecting rods and cranks, and, in one arrangement, the inner wheels, of large diameter, were to rest on the main track supporting the wheels of the carriages and trucks forming the train. The outer wheels, on the contrary, rest upon the special tracks laid at a higher level than the others whereever steep gradients are encountered.

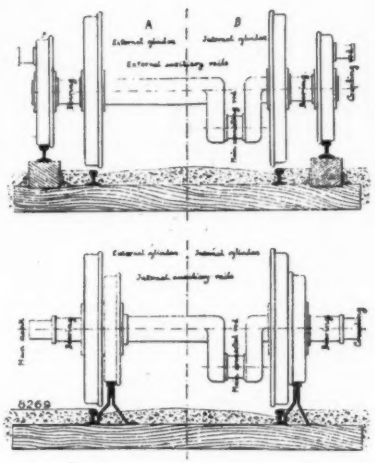


FIG. 2.

An alternative method placed the main and special tracks in the order shown in the lower drawing, Fig. 2, which permitted of a reduction in the overall width of gauge and necessitated a re-arrangement in the position of the wheels on the driving axle.

The process of changing from one set of wheels to the other, and from the wider gauge to the narrow one, was to be automatically performed, without the aid of the engineman. When the locomotive was resting on the outer wheels the inner ones "would act as fly-wheels and regulate the motion and, oppositely, when it rested on the inner wheels the outer ones would carry out the same function."

Another inventor sought, at a slightly later period, to effect a means of storing power, utilising the resistance offered by the atmosphere to railway trains or locomotives in motion. He proposed to mount on the front of the locomotive a fan or wheel of such form that when the locomotive was in motion the atmospheric resistance would cause such fan or wheel to revolve at a considerable speed, and the power so developed was to be transmitted to any suitable machinery or apparatus by

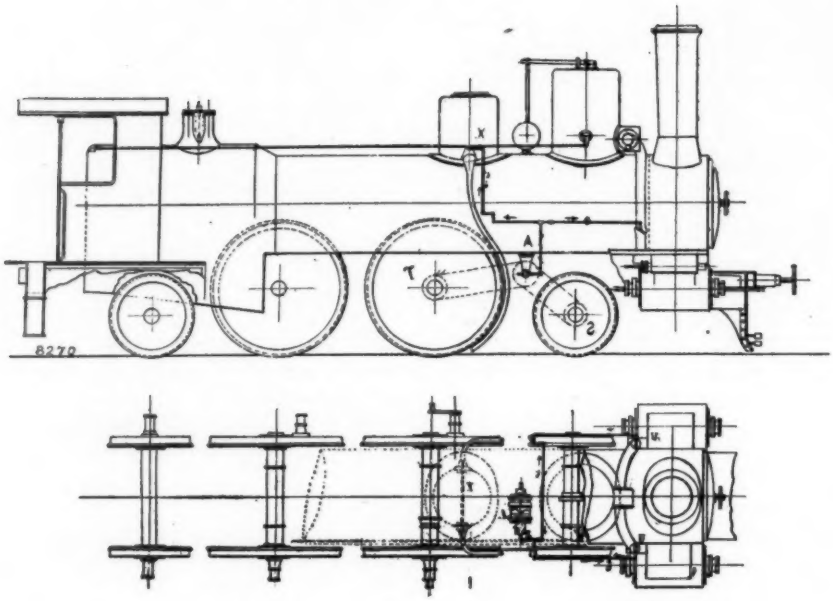


FIG. 3.

means of which it could be readily applied to or stored for any useful purpose. Among other useful purposes which the apparatus was intended to serve were those of producing electric light and applying the brakes. It is hardly likely that the plan was ever tried in actual practice, at any rate on any of the railways of this country.

The very numerous inventions having as their primary object increase in the power of the locomotive, and which generally sought to accomplish their purpose by calling in the aid of additional mechanism with a consequently greater amount of friction, have been quite equalled in number by those aiming at the prevention of loss of power through slipping of the driving wheels. Some of these latter were of a remarkable character, and, if adopted, would certainly have caused greater and more continued loss of power than would the evil they were designed to overcome. Others, of course, presented valuable features, and were quite within the sphere of practical utility, but it is probable that none would equal in efficiency the plan now generally adopted, viz., power sanding. The drawings, Fig. 3, and the following description of the device they represent, both of which apply to an invention patented a little over twenty years ago, will serve as a useful example. The object was to provide means for arresting slipping of the driving wheels the moment it occurred, and this was to be accomplished in such manner that directly slipping began the steam would be shut off and sand deposited upon the rails, the two operations taking place automatically and independently of the driver. To secure this automatic action a shaft, carried in bearings between the axles of the driving and running wheels, had mounted upon it a pair of chain wheels which were respectively connected to the two halves of a clutch.

The adjacent faces of the clutch are undulating, or of such a form as to engage with one another in their normal position, but to cause the separation of the two halves of the clutch when one part of the latter is rotated independently of the other. If the driving wheels slip, that half of the clutch which is revolved by them will rotate at a greater speed than the other half, the result being that the clutch faces will move over one another and cause the two halves of the clutch to separate, thereby imparting a lateral movement to the shaft which is connected to the regulator valve and the sand box, the movement of this shaft shutting off steam and opening the supply of sand to the rails.

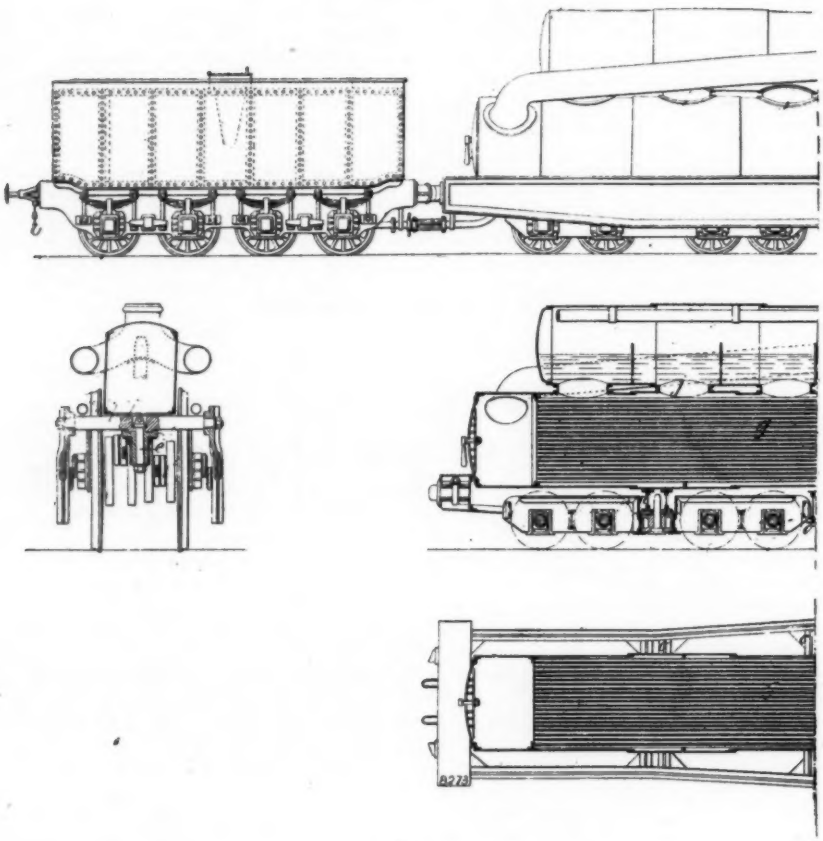
This method, although somewhat involved, was by no means devoid of merit.

Means whereby locomotives might be enabled to attain high rates of speed have received a full measure of attention from successive inventors, the majority of whom have taken as the basis of their plans the employment of very large diameter wheels. This principle has in many cases been extended to the tender also (where such has been used). Locomotives constructed in accordance with it were, in the first place, to have imparted to them greater stability and safety against running off the rails by reason of the centre of gravity being lowered; secondly, to be capable of increased speed by the use of wheels of much larger diameter than usual; and, thirdly, to obtain easier motion and decreased wear and tear by a system of double suspension of the "body" of the locomotive. Briefly the boiler and the machinery of the locomotive were suspended by transverse beams from springs carried by a longitudinal frame, which, in its turn, was supported on the wheels by other springs. The cylinders were placed outside the longitudinal frame, being carried by brackets projecting from the boiler.

These brackets carry two opposite ends of vertical bars or rails which bear against rollers carried by transverse bearers on the frame, so that as the frame vibrates up and down relatively to the boiler and its brackets, these rollers rise and fall upon the said rail, thus allowing freedom of motion for the parts, whilst the brackets and cylinders are afforded a solid abutment against the frame in either direction. The body of the tender was similarly arranged. One of these locomotives, if not more, was actually put into service on the French State Railways, but the type, as may readily be supposed, never became standard practice.

A few years later another inventor set himself the task of producing a locomotive which should combine the desiderata of largely increased power and speed "within permissible dimensions, and that without sacrificing stability." The manner in which he proposed to effect this may easily be gathered from the drawings, Figs. 4 and 5. The boiler was divided from the engine so that the locomotive, as a whole, consisted of a front part, including engine and driving wheels, and, above them, the fuel supply and a hinder part consisting only of the boiler, the whole to be completed by appending a tender for carrying water. The front end of the engine was to be supported upon a four-wheeled bogie, and the cylinders were located at this end also.

The connecting rods actuate cranks on the driving axle, which is coupled to a second and sometimes a third driving axle, not by side rods on the wheels in the ordinary manner, but by a pair of coupling rods underneath the boiler. All the machinery is therefore within the framing, as near as possible to the longitudinal axis, so as to avoid the alternating impulses on each side when the cranks are externally placed. The framing of the engine portion consists chiefly of a central longitudinal girder and two side girders outside the driving wheels with suitable cross ties. Above the engine there is a floor and an enclosed space for fuel; this, as well as the part below, being preferably made with a conoidal front, so as to diminish

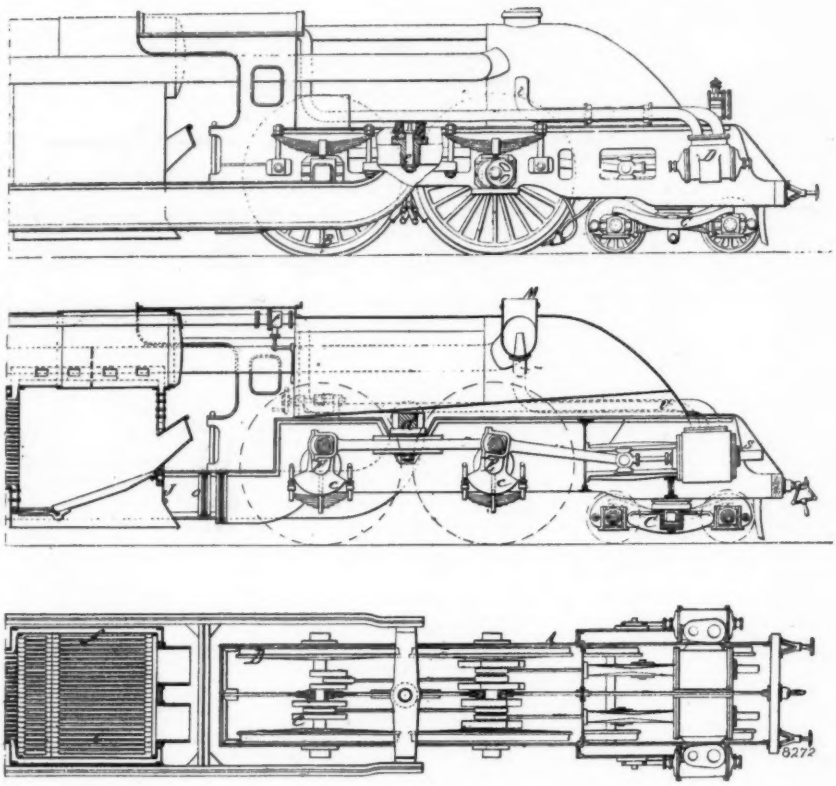


(Continued on opposite page.)

FIG. 4.

resistance of air at high speeds. The enginemen's cab is located immediately behind the fuel store, the footplate occupying the space between the latter and the boiler. The hinder part of the boiler is carried on a pair of four-wheeled bogies or on one having eight wheels. The front portion has two rigid side frames projecting forward from it to a crosshead, the centre of which is pivoted in a spherical bearing on the engine frame midway between the two driving axles. Thus the weight of the front part of the boiler is transferred to the driving wheels, while, at the same time, the boiler and engine are free for independent movement on curves.

In 1894 a patent was taken out, the object of which was to provide a means by which engines of long wheel base could be made to easily travel round curves of short radii (Fig. 6). With this purpose in view, the inventors adopted the plan of coupling certain axles directly, instead of through the medium of crank pins in the wheels, and the cranks on the axles were to be formed with curved or ball-bearing surfaces, the central coupling rod being formed



(Continued on opposite page.)

FIG. 5.

with a correspondingly curved bearing with a slight allowance for play between the two arms of a crank.

The axle boxes were also to have a slight play in a direction at an angle to the axle, one axle box sliding forward while the other moved to the rear, thus allowing for the necessary turning of the axle. To permit of the required motion, the axle boxes were recessed about 2½ in. wider than the shoes and ridges.

The four-cylinder balanced compound locomotive arranged for working as "simple" when desired by the driver, in order to obtain temporarily increased power, is generally regarded nowadays as one of the latest developments in locomotive practice; indeed, upon a large number of railways the type is still one of the future. Yet the idea of so constructing locomotives was thought out very many years ago in this country, although to France belongs the credit of first adapting the type under anything like modern conditions. In the early eighties a Mr. Daniel McIntosh Reid, of London, patented an invention which aimed at securing economy in steam and fuel consumption by employing compound working on level and easily graded sections of the line, and "by having a large cylinder capacity adapted to be instantaneously changed from compound to simple engine system, to have a command of power for steep

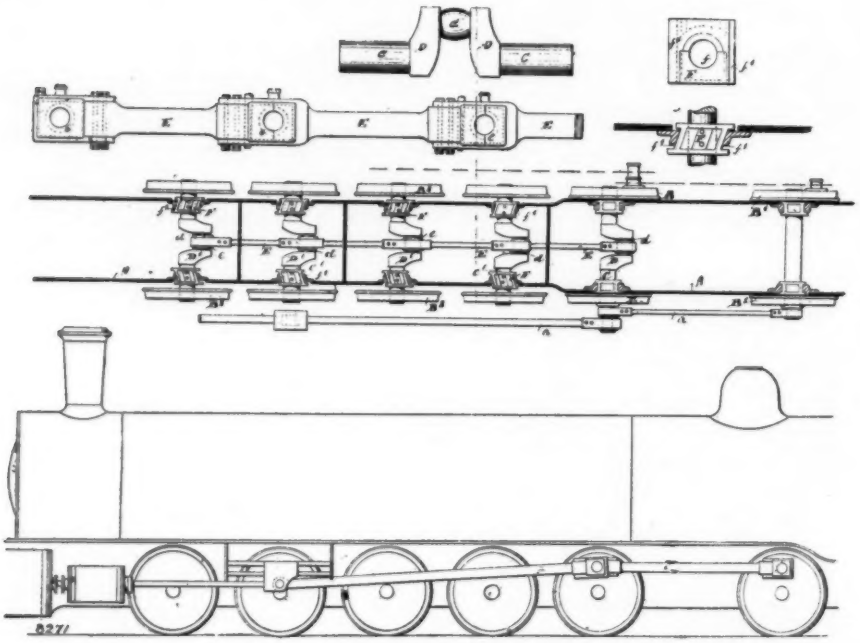


FIG. 6.

gradients, and for starting heavy trains equal to two ordinary engines of similar size." The drawings (Fig. 7) clearly illustrate the arrangement of the cylinders, cranks, etc., which are shown applied to a tank locomotive of the 2-4-0 type. The four cylinders are carried in advance of the leading wheels, with the high-pressure cylinders between the frames, driving the crank-axle of the front coupled wheels, and the low-pressure cylinders outside the frames, driving on crank pins in the same pair of wheels. The two cranks on each side (one high and one low-pressure) are placed opposite one another (180 deg.) and at right angles (90 deg.) to the other pair, thus locating a crank-pin on every quarter. The four steam-distributing valves are worked by two sets of link-motion driven by eccentrics on the crank-axle, the valves being worked by two suitably arranged rocking-bars, having connections between the outside and inside valve-spindles and the reversing link die blocks. The single valve motion and reversing gear is thus arranged to work a double set of valves. The method of changing the engine from compound to simple working or *vice versâ* is thus described:

"The exhaust steam pipe (through which the exhaust steam passes from the small to the large cylinder when working under compound system) is employed as a valve casing for what are called the exhaust division valves. The two valves are fastened to a bracket arranged inside the pipes, one at each end. The one at the high-pressure cylinder end closes the high-pressure exhaust port on the top of the diversion pipe when working under compound system, and while it is closed the low-pressure valve, at the opposite end, is fully opened, thus admitting a free passage of the high-pressure exhaust to the low-pressure valve chest. The low-pressure valve and port are situated at the bottom of the opposite end of the diversion pipe. This port is closed and the other opened when all four cylinders are working under high pressure. The valves are worked by a small pinion acting upon the bracket, from which a spindle extends

to the footplate, by which the action of the valves can be instantly changed from simple to compound. The throttle valve and steam pipe leading to the inside valve chest are of the ordinary inside-cylinder locomotive description. The throttle valves and steam pipes leading to the outside (l.p.) cylinder valve chests by which high-pressure steam is supplied to the large cylinders, when they are being worked simple, are arranged outside, extending from the fire-box end of the boiler, where the throttle valve cases are arranged conveniently near the main throttle valve to admit the employment of a simple gear connecting the three valves when all the cylinders are working at high pressure. This arrangement is necessary so that the steam may be shut off from and applied to all four cylinders together as in case of slipping when working heavily."

The inventor proposed that the high-pressure cylinder should have a diameter of about 14 in. and a stroke of 17 in., whilst the proportions of the low-pressure cylinders were to be about 18 in. by 22 in. The boiler was to have a diameter of 5 ft. (an unusually large diameter twenty-five years ago), but the inventor evidently recognised the necessity of providing ample boiler capacity to meet the increased rate of steam consumption when all four cylinders were working simple.

As a concluding example of the attempts made by inventors to improve the locomotive, brief reference to a project, put forward in 1894, for combining steam and electric traction in the same locomotive will in these later days—when electricity has become such a powerful rival of steam on railways—be of rather more than usual interest. Said the patent specification, "The motive powers to be used and combined in this invention are steam and electricity, so that steam may be available for the open and electricity for the tunnels, with the main object of keeping the latter free from smoke and fumes." The locomotive shown in Fig. 8 is of a type following that used on the Metropolitan Railway ever since the early days of that line, and the inventor proposed to improve on this by mounting "armatures or electric motors, the corresponding field magnets and other accessories being arranged to suit." Current was to be taken up from a

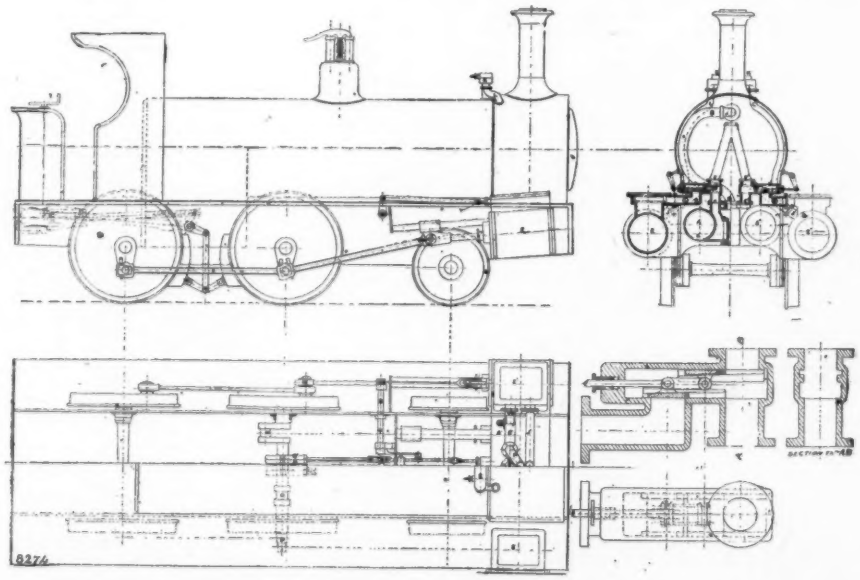


FIG. 7.

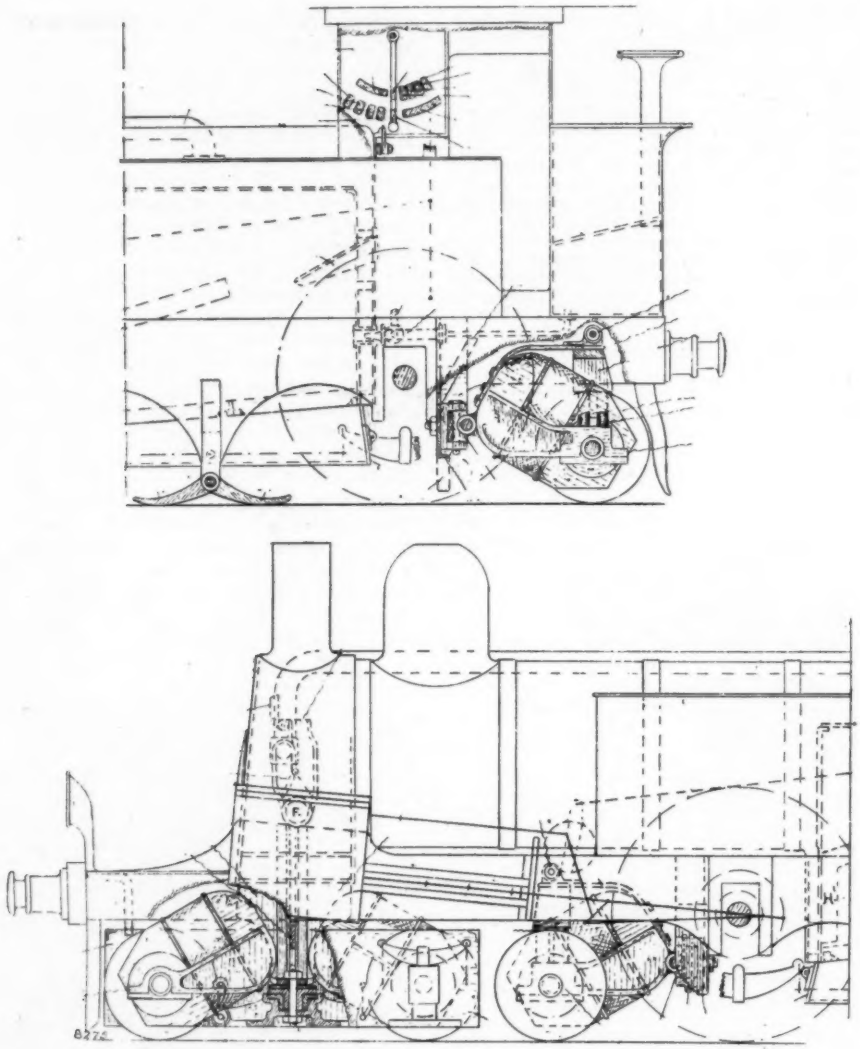


FIG. 8.

conductor rail laid between the metals. The two small pairs of wheels are arranged on the bogie principle. The ordinary mechanism for controlling the engine when working under steam was to be fitted, and a main electric switch board placed in the cab for regulating the action of the electric motors.

The inventor must have been possessed of a very sanguine temperament if he really believed that his scheme would be taken up and applied

to practical uses on railways, but then if optimism were not one of the principal traits in the average inventor's character, there would be little need for such an elaborate patent law system as that now existing, the administration of which provides employment for immense numbers of workers in all parts of the civilised world. The limited space at the writer's disposal prevents the subject being further pursued, but enough has been said to show how important a part has been taken by inventors in the development of the steam locomotive.

The Electrical Operation of Textile Factories.

By T. W. SHEFFIELD, A.M.I.E.E.

PREJUDICE dies hard in most industries in this country. It is said to have a more lingering death in the textile industry than in any other. That may, or may not, be true, but it is a fact that the introduction of the electric drive in the cotton mills in Lancashire met with a storm of opposition which was kept up relentlessly for some years. The opposition was based on all sorts of statements by employers and employés, but recent passing events and the success of the pioneer schemes in Lancashire have proved that it was mostly a matter of prejudice. The writer was instrumental in securing one of the first schemes for the electrical driving of looms, some six years back, and can assure the readers the word "prejudice" used in the above remarks is employed in its true sense. Notwithstanding the opposition, there has during the last two years been some 20,000 h.p. of motors installed for driving textile machinery in the County Palatine, and a number of important schemes are under consideration.

Having regard to the probable extensive future adoption of electrical driving of textile factories, it should be mentioned that there are over 2,000 firms engaged in the process of spinning and weaving of cotton, and they operate in round figures 51,750,000 spindles, and 7,030,000 looms.

These figures were taken from records carefully compiled by the leading cotton association of Manchester up to the end of 1906.

In the writer's opinion there are several reasons which have retarded the adoption of electric driving, which may be briefly enumerated as follows:—

(*a*) The chief cause of the matter not being taken up during the period ending 1904 was the depression which existed in the textile industry during the preceding years; (*b*) the great wave of re-action and healthy state of trade during the last two years has had a tendency to keep the question of the electrical drive in the background, as manufacturers have been too busy earning fat dividends to make alterations which would involve any stoppage; (*c*) the natural conservatism of this country, and especially in the textile industries, which causes manufacturers to wait until someone else has tried a new venture before experimenting themselves; (*d*) progress has been retarded by the number of contradictory statements which advocates of electrical driving have, in their enthusiasm, put forward with sometimes exaggerated estimates as regards increase of production, efficiency of transmission and particularly economy of coal, which it was perfectly impossible to guarantee under any electrical scheme. This has been the fatal error of many enthusiasts as they know by now only too well. The mill-owner and mill manager is generally very well up in all details of his own costs, and has condemned electrical driving altogether, because in his opinion the cost per h.p. hour with an

ELECTRICALLY DRIVEN RING SPINNING FRAMES. GENERAL ARRANGEMENT OF SPINNING ROOM

electrical plant did not compare favourably with a mill engine and rope transmission. It is still doubtful, even in the case of a new mill, if any considerable economy of fuel could be shown by adopting electrical driving, and it is not advisable to advocate the system on this ground.

Further objections are urged against the electrical drive which it will be necessary to allude to in connection with the foregoing statements :—

(1) That the efficiency of the mechanical drive is considerably higher than that of the electrical; (2) the reliability of the electrical drive has not been sufficiently proved; (3) that the increased capital expenditure involved in the adoption of the electrical system is excessive when compared with mechanical driving; (4) that the electrical system only shows advantages in special cases, or when the average load factor is low.

With reference to the last objection, the writer has met people interested in the textile industries who admit that it may be an advantage to adopt electrical driving in old mills, or when the buildings are at right angles to each other.

The first objection, which is the most discussed, is difficult to dispose of by any single statement, as the basis for argument is not sufficiently good to enable one to say exactly which view is correct.

The writer was connected with some experiments carried out, which involved amongst others the driving of four mule spinning frames by a single 50 h.p. induction motor. The first experiment was for a period of three weeks, the motor driving the frames from a line shaft through an ordinary rope drive, and records of the power taken were obtained from an integrating wattmeter.

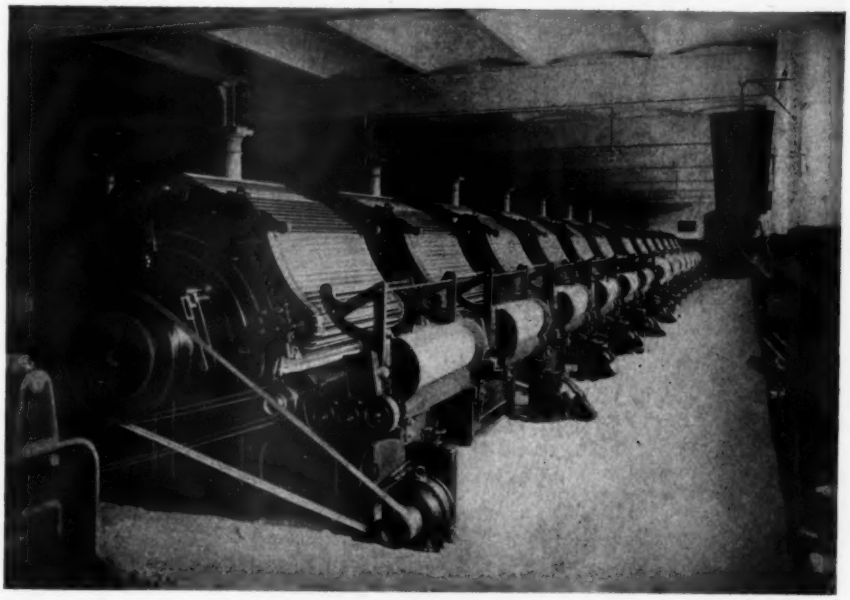
In the second experiment the motor was direct coupled to the line shaft through a flexible coupling, and ran for another period of three weeks, the mules running the same number of hours per week and spinning the same counts.

With the rope drive eliminated the production was somewhat increased, and the average power taken for the whole period reduced by between 12 and 13 per cent. From this it is fairly obvious that the more belt or rope drives introduced in the transmission, the lower must be the efficiency, and those who argue that with the most modern forms of rope drive it is possible to obtain efficiencies of 98 per cent. are considerably over-estimating the actual results obtained. The question of efficiency will always be a debatable one, as accurate figures are difficult to obtain, and it is generally admitted that in most modern mills the results are very good indeed with the mechanical drive; but it is very much to be questioned if a better result than 80 per cent. is ever obtained.

The customary method of arriving at the efficiency of a mechanically driven mill by taking no load and full load diagrams on the engine and then calculating from them the percentage loss in transmission is, whilst attractively simple, an unsatisfactory plan.

The main reasons for the adoption of electric driving should be urged on a broader basis; the advantages which accrue from the electrical operation of textile factories are mainly as follows:—

(*a*) The internal arrangements of the mill as regards shafting, gearing, belt and rope drives, &c. are very much simplified and their costs reduced; greater flexibility as regards extensions, and no right angle drives are required should the new section be built at right angles to the present building: (*b*) the mill and engine house can be placed each in its most convenient situation without any regard to their relative position: (*c*) the arrangement of the frames is much less arbitrary than in a mechanically driven mill; no heavy main shafting and rope race is required; the motors and the comparatively light shafting required by them can be placed where most convenient: (*d*) the chance of a breakdown which would stop the whole mill is



ELECTRICITY IN SPINNING MILLS. INDIVIDUAL DRIVE OF CARDS.

reduced to a minimum: (*e*) a smaller engine house is required: (*f*) maintenance and depreciation charges are reduced: (*g*) greater steadiness of the drive, the percentage of the fluctuation of the speed being as low as 1½ per cent. when running under suitable conditions, with a subsequent perm ssible higher speed and increased output: (*h*) a complete check of the power used in each room or section of the mill is rendered possible.

It may also be pointed out that when the factory reaches a certain size, fairly well defined, the cost of the installation of an electrical transmission system is no greater than the ordinary mechanical plant, and as the size increases the electrical scheme has an actual advantage in initial capital outlay.

Another point is the reduced number of overhead shafts, pulleys and belts, permits of perfect and efficient lighting, gives greater facilities for handling goods, and gives increased ventilation and general sanitation of spinning rooms.

In textile industries cleanliness is a most important item. With belt transmission at high speeds oil is thrown about, and the atmosphere is constantly charged with dust and dirt which is kept in circulation by the belts. In every case where electrical transmission is adopted greater cleanliness is obtained, and an increase in this means higher economy and efficiency of machine and employé.

ELECTRICITY IN SPINNING MILLS. INDIVIDUAL DRIVE OF FLYERS

Electrical plant is remarkably reliable and free from breakdown; when this does occur the results are comparatively slight, in that only a part or single room of the factory is stopped.

Among the many machines which are accessories to the textile industry the ring spinning frame is one of the most important, and is eminently suitable for electric driving. The main reasons why the electric motor is applicable here are its reliability and the ease with which its speed can be regulated. Although continuous current motors, if well designed, meet the case, the best motor for the purpose is the single-phase

commutator motor or three-phase induction motor with wound rotor embodying the above good points in their favour, together with that of good starting.

With the single-phase commutator motor tests have been made with a machine with a constant speed and a machine with varying speeds, and the writer's informant found that many more breaks took place in the former case. The spinning time can be divided as follows:—

(1) Starting the motor, 0-550 r.p.m. 3-5 secs.; (2) starting period, 550 r.p.m. 2 min.; (3) main spinning period, 785 r.p.m. 10-12 min.; (4) finishing period, 650-600 r.p.m. 2 min.; (5) stopping the motor, 600-0 r.p.m. about 5 secs.

From this it will be seen that the production of the ring spinning frame must be much higher than when the speed is kept constant at 650 r.p.m.

These tests were only made with one sort of yarn, and various qualities may affect the speeds, but it is probable that the speeds during the various periods keep in the same proportions. It is accepted by those qualified to judge in Lancashire that the principle of one frame, one motor, is correct, although up to the present it has not been usual to run ring spinning frames from separate motors, as the initial cost is higher than that of a transmission. But using variable speed motors the greater production rapidly compensates for the extra cost of the self-contained installation. It may be interesting to mention that in some such installations now being erected, single-phase commutator motors are being fed from the ordinary three-phase distribution network, the consuming units being equally divided on all three phases.

The driving of mule spinning frames is the most difficult problem to be dealt with in the electrical equipment of a textile factory. The variation in load during the cycle of operations, which takes from 9 to 20 secs. to complete, is enormous and such as to practically make the running of single frames from individual motors impossible. The load with a large frame may vary during the cycle from zero to 50 h.p., and in order to get anything like a steady load the grouping of a number of frames on a single motor is imperative. Twelve frames on a 150 h.p. motor would represent good average practice. A smaller number of frames are being successfully run, but usually some preparation machinery is also driven from the same motor in order to even up the load.

Recent speed tests taken with "Moscrop" recorders show a variation of 12 to 20 per cent. in some cotton mills when driven mechanically. These variations have been reduced to less than 2 per cent. in one or two cases—the average variation being 2 per cent.—when driven electrically. Not only does this give a greater output but the quality of the yarn is better. This is really the most important benefit to be obtained from electrical driving. An increased output of from 7½ per cent. to 12½ per cent. in the production of a given number of spindles with an improved grade of product will justify a considerable capital outlay, and when it is remembered that in the case of a large mill the capital invested may not be increased at all, the argument in favour of electrical driving is very strong.

During the last twelve years the United States mills, with a spindle capacity of about one-third of that of Britain, have installed some 200,000 h.p. of motors.

In the last three years British mills have taken 20,000 h.p., and it is obvious, therefore, that the field before the electrical manufacturer in this industry is a very valuable one and well worthy of careful attention.

ABSTRACTS OF RECENT PAPERS ON THE SUBJECT OF THE ELECTRICAL OPERATION OF TEXTILE FACTORIES.

1.—H. W. WILSON, A.M.I.E.E., before the Manchester Local Section of the Institution of Electrical Engineers.

THREE years ago the actual horse-power of motors installed for driving textile factories in Great Britain was limited to a few hundreds, practically all in one mill, and only a very

small fraction of the then total was actually in cotton mills.

So far as it has been possible to estimate from answers to inquiries sent by the various firms interested, the total horse-power which will be installed and running by about the end of March, 1908, will be about 28,000, and this is almost entirely in cotton spinning mills. These figures show, of course, that a very distinct progress has been made, and that the conservatism of the textile manufacturers with regard to the driving equipment of their factories is being slowly broken down.

When, however, it is considered that in the United States and Canada there is something like 250,000 h.p. of motors installed in textile factories, and that the orders for such machines received by one firm during the past half-year, for supplying various mills in the States, amounted to about 25,000 h.p., or practically as much as has been done in this country in three years, and when besides it is remembered how very much the total power requirements of the British mills exceed those of the United States, it will be recognised what immense room there is for further development here.

Every one agrees that for work of the class under consideration a 3-phase equipment has decided advantages over a direct current, and in the absence of a satisfactory single-phase motor for anything except very low periodicities, there is no doubt that the present general course of action will continue.

It is quite obvious that an induction motor, either squirrel-cage or slip-ring, made by one manufacturer does not differ very materially in its performance from a machine of the same class made by another, and that provided the same guarantees as to the behaviour of the machines are given by any two firms the results which will be obtained when in operation will be the same. It may appear unnecessary to emphasise this point so much, but it must be remembered that persons who are not electrical experts, and having very little knowledge of the actual design of electrical machinery, are apt to be misled by manufacturers who state theirs is the one and only system which will give perfect results in operation. There is no special system in the driving of a textile factory which will inevitably give the best results, but there is scope for the exercise of an immense amount of judgment and knowledge of the conditions to be met in the arrangement for the driving of the various textile machines.

The advantages which the advocates of electrical driving urge for the operation of large textile factories are as follows :—

1. The mill and the engine house can be placed each in its most convenient situation without any regard to the relative positions. 2. The internal arrangements of the mill as regards shafting, gearing, belt and, rope drives, etc., are greatly simplified and their costs reduced. The flexibility as regards extensions is, of course, obvious. 3. The grouping of the machines is much less arbitrary than in a mechanically driven mill, as the motors and the comparatively light shafting required by them can be placed where most convenient. 4. The reduction of the chance of a breakdown, which would stop the whole mill, to a minimum. 5. The ease of running one section for overtime or on special work. 6. The reduction of the maintenance and depreciation charges. 7. The greater steadiness of drive which can be obtained under suitable conditions, with a subsequent permissible higher speed and increased output. 8. The reduction in the total capital cost of the mill per spindle or per loom with a factory of above a given size. 9. The possibility of keeping a constant check upon the results obtained in each department of the factory.

In addition to these advantages it may now be claimed that a better price can be obtained for the product of an electrically operated factory than for that of a mechanically driven one, and as regards this point I have definite information that this statement is correct, though I am not at liberty to give the exact figures or to mention any names.

It is also a fact that Clause 7 in the above list has now been proved conclusively, but in this instance also the manufacturers display considerable disinclination to allow the publication of definite figures, though some of them are prepared to admit that they would continue electrical driving even at a greatly increased cost on account of the much better results which are being obtained. It might be mentioned, however, that in the case of one large installation which has recently started work that the management in making their calculations admitted that from the evidence before them they were certain to obtain an increase of output when the mill was being driven electrically, and they took this fact into their calculations.

The objections referred to previously are as follows, and so far as I am aware no further serious points have been raised by the opposition side.

The first objection is that the reliability of electrical driving has not been sufficiently proved.

Secondly, that the capital expenditure involved in the adoption of the electrical system is so great in comparison with mechanical driving, as to put it out of court.

Thirdly, that it is only advantageous in special cases or where the average load factor is poor.

Fourthly, that the efficiency of a mechanical drive is considerably higher than that of an electrical one.

The first objection may now be regarded as finally demolished, as of recent times I have never found that even the most bigoted objectors tried to contend that electrical machinery was not reliable in operation, and when it is considered that at the present time 3-phase motors are working with perfect satisfaction under the very severe conditions of mining and

rolling mill work, it is fairly obvious that the comparatively light duty of a textile factory presents no difficulty whatever.

The second objection, which is almost answered by the eighth clause of advantages, may now be fairly definitely withdrawn from the list. The capital expenditure is, of course, high when a small factory is being considered, but with a large spinning mill of, say, 100,000 spindles, after making allowance for all the structural alterations which can be effected, there is absolutely no increased capital expenditure, and if the factory increases in size beyond this limit the electrical equipment will work out more cheaply than the mechanical. The important items, of course, are the total abolition of the rope race, which under ordinary conditions is an expensive structure, and the reduced cost of gearing. There is one example of a factory in this neighbourhood which is electrically driven, but where the rope race was built in order to allow of mechanical driving if the electrical proved unsatisfactory; this course is not likely to be followed in the future.

The fourth objection is still brought forward with commendable regularity, and it is in the nature of the case a very difficult thing to disprove. The actual efficiency of an electrical system of driving can be ascertained easily, but the efficiency of a mechanical system under running conditions it is impossible to obtain accurately. It may, however, be of interest to note that where a mill has been converted from a mechanical drive to an electrical one, the i.h.p. of the prime movers has been reduced with the same machinery running, and this certainly tends to show that the efficiency of mechanical drives is not usually as great as stated by its advocates. The probability is, however, that as between a well laid out electrical drive and a perfectly modern mechanical drive there is very little difference indeed in the actual efficiency of transmission —that is to say, as regards the total power delivered to the machines by the driving mechanism. This does not, however, dispose of the fact that the motors deliver the power in a rather better manner—that is, at a more constant speed.

Three years ago it was stated that for the preparation machinery including bale breakers, blowing machines, scutchers, cards, combers, roving and intermediate frames, group driving was the correct course to pursue, and when considerations of the capital cost are taken into account, there is still no doubt that this is the best practice.

It was also then stated that for mule driving the grouping of the machines was essential, and this statement held good until very recently. My own experience certainly points strongly to the advantages of a group drive for this class of machine, but recently satisfactory results have been obtained from a motor driving a single mule with a suitable arrangement of fly-wheel effect in the system. It would seem doubtful even yet whether as good results can be obtained from this as from a group drive, although the users appear to be perfectly satisfied; but it is certainly worthy of interest to note that successful results have been obtained at all, considering the exceedingly variable load that a single mule spinning frame gives.

The keenest argument over group or individual driving has arisen in connection with ring-spinning and ring-doubling frames. These machines individually give a practically constant load, and it is a very simple matter to couple directly a motor of, say, from 5 to 10 h.p., according to the size of the frame, to the machine and thus do away with all possible slip or transmission losses. It is, however, to be remembered that in a number of factories the ring frames are not always spinning the same class of counts, and, in consequence, a speed variation of the spindles becomes necessary. To effect this variation, in a large number of cases slip-ring machines with wound rotors have been installed, and the variation is obtained by inserting resistance in the rotor circuit.

There are three objections to this arrangement, which is, of course, in other respects a most convenient one, the first being the initial capital outlay upon the installation; the second, the low efficiency of the motors when running with the resistance in circuit; and thirdly, the objection which has several times been expressed to the heating of the resistances, which has sometimes been the cause of considerable annoyance. Textile manufacturers are generally apprehensive of the heating of resistances to a temperature which, from an electrical standpoint, is perfectly safe, but which they regard as dangerous; and as the ordinary factory is always at a fairly high temperature, it is difficult to get efficient cooling without building rheostats of abnormal size. It would therefore appear as if in future installations of this character special cooling arrangements would have to be considered.

In cases where individual driving is adopted, but where speed variations on the spindles is not necessary, squirrel-cage motors with some form of a friction clutch as a coupling have frequently been used, and have satisfactory results. The capital outlay on these machines, including the clutches and auto-transformer starters, is distinctly less than upon the wound-rotor machines with regulating resistances, even although in this case the clutch coupling is not necessary.

The alternative arrangement for the driving of frames where variable speed is essential is to group the machines and drive with a single motor, changing the pulleys for speed variation, as is customarily done with the mechanical arrangement.

Arising from this question of the method of driving is the possibility of direct coupling the motors to the line shafts in nearly all cases for group driving, and this course of action has now been found to be possible to a greater

extent than the manufacturers were at one time prepared to admit.

Having become accustomed to certain shaft and pulley speeds as being on the whole the most convenient for a mechanical transmission, considerable difficulty was found in inducing them to depart from what they regarded as a standard arrangement; but it is now, in nearly all cases, found possible to speed line shafts up to an extent that will permit of direct coupling to standard speed induction motors without any objectionable results arising. This arrangement materially reduces the transmission losses between the prime-movers and the textile machines and also eliminates some possibilities of slip.

Electrical manufacturers generally do not appear to realise that the actual powers required need very careful investigation before the machines are actually installed, and it is by no means a safe rule to assume that the horse-power is so much per one hundred spindles of the mill, as this may lead to considerable error. If a large mill engine is being put down to drive the whole of the plant, it may be perfectly safe to use such general assumptions; but when what is practically equivalent to a sub-division of the prime-mover is made, the most careful consideration of the power taken by each section of the installation is essential.

In considering this it is necessary to know the class of material which is to be produced, as figures from one mill only would be very misleading applied to another mill with the same class of machines but manufacturing a different grade of material.

Regarding the question of the prime-mover, if the mill has its own installation, one approaches a subject which is open to practically endless discussion. Installations either in operation or approaching completion comprise standard mill engines driving generators through ropes, mill engines direct coupled to generators, quick-revolution generating sets, and turbo-generator sets. It is only needful for a gas-driven set to be installed to have complete examples of almost every type of prime-mover which is possible in this country.

From the point of view of perfect angular velocity the turbine offers obvious advantages, and, in addition to this, for large sizes the capital cost per kilowatt is fairly reasonable.

Mill-owners generally, however, seem to have a prejudice against steam turbines, apparently on account of one or two unfortunate experiences; but these do not appear to justify the sweeping condemnation sometimes indulged in. At the same time, it does appear to be a fact that a steam turbine is not altogether as reliable a machine as a reciprocating engine, and recent practice seems to be in favour of installing two turbines, either of which is of sufficient size to run the mill by utilising to the full its overload capacity.

I.—Comparison of Capital Outlay for a Spinning Mill of 100,000 Mule Spindles—Driven: (*a*) By Ordinary Mechanical Means; (*b*) By Three-phase Elfctrical Transmission.

(*a*) Mechanical.	£	s.	d.
Engines, piping, etc., erected	6,000	0	0
Boilers	2,000	0	0
Chimney and boiler seatings	1,000	0	0
Reservoir	1,500	0	0
Engine house	600	0	0
Engine bed	600	0	0
Rope race	500	0	0
Boiler house	500	0	0
Economiser and house	750	0	0
Lighting generator and seating	1,200	0	0
	£14,650	0	0
Gearing	3,000	0	0
Total	£17,650	0	0

(*b*) Electrical.	£	s.	d.
850-k.w. turbo-generator and auxiliary comp.	6,600	0	0
Boilers	2,000	0	0
Chimney and boiler seatings	1,000	0	0
Reservoir	1,500	0	0
Engine house	400	0	0
Engine bed	300	0	0
Motors, cables, and switchboard	2,982	0	0
Boiler house	500	0	0
Economiser and house	750	0	0
	£16,032	0	0
Gearing, £550; pulleys, £250	800	0	0
Total	£16,832	0	0

II.—Comparison of Running Costs for a Spinning Mill of 100,000 Mule Spindles.—Driven: (*a*) By Ordinary Mechanical Means; (*b*) By Three-phase Electrical Transmission.

(*a*) Mechanical.	£	s.	d.
Coal, 1,500 i.h.p.	1,350	7	6
Wages—Engineer, 55s.; assistant, 30s.; two stokers, 28s.	352	10	0
Oil, etc.	125	0	0
Insurance—E, £100; B, £22; gear, £60; buildings, £20	202	0	0
Rates, 7s. on 5 per cent. of £14,650	256	7	6
Interest and depreciation, 12 per cent. on £17,650	2,118	0	0
Total	£4,413	5	0

(*b*) Electrical.	£	s.	d.
Coal, 1,400 i.h.p.	1,268	15	0
Wages (no assistant)	277	10	0
Oil, etc.	125	0	0
Insurance—E, £100; B, £22; gear, £16; buildings, £10	148	0	0
Rates, 7s. on 5 per cent. of £16,032	280	15	0
Interest and depreciation, 12 per cent. on £16,832	2,019	15	0
Total	£4,119	15	0

Cost per kilowatt-hour for 850 kilowatts, 56 hours per week and 50 weeks per year.
= 445*d*. = 415*d*.

Note.—Coal cost based on 2 lb. per i.h.p., 7s. 3*d*. per ton, 56 hours per week, 50 weeks per year.

My own preference for a mill of, say, less than 1,000 h.p. would certainly be in favour of a quick-revolution reciprocating set, but the slow-speed engine makers are now prepared to guarantee such favourable results in steam consumption that in spite of the extra capital cost their claims demand careful consideration. There is, of course, the added advantage that the average mill engineer is more familiar with the slow-speed engine than any other type, and under ordinary conditions repairs and maintenance will be a small item.

It must be remembered that the ordinary mill engine runs about 55 or 56 hours per week under practically full load, and that it is usually of 700 to 1,500 h.p. in size. It is manifest also that with the distinct advances which are being made in gas-engine design that gas-driven generating sets will in the future demand consideration. Particularly is this the case as the makers are now prepared to guarantee very constant angular velocity, which in the past has been one of the principal drawbacks of gas engines for the class of work under discussion, where constant speed is of the utmost importance.

It might be mentioned, in passing, that in the case of one mill supplied from a central station the mill authorities stated they were able to tell by the behaviour of the machinery when they were being run off the steam turbines and when off the reciprocating engines, and very much preferred the former.

The other point is that of power supply from a central generating station. Of the total horse-power in motors now installed in textile factories in this country some 25 per cent. to 30 per cent. are driven from central generating plants, and this proportion shows every sign of increasing rapidly.

As a matter of fact, upon the occasion of reading the previous paper, I did not feel that the central supply authorities would be able to induce proprietors of spinning mills to take a supply at a price much above 0·35*d.* per unit in the case of large mills in the Lancashire district, where coal is cheap. This, however, is merely another case showing the unwisdom of prophecy, as it is common knowledge that some large factories are now paying considerably above this price, and are perfectly satisfied so to do; and, as regards mill-power costs, I would refer you to Schedule II.

II.—W. B. WOODHOUSE, Chief Engineer to the Yorkshire Electric Power Company, before the Bradford Engineering Society.

In all parts of the world where textile manufacture is carried on, there has been in the last few years a rapid spread of the use of electric power for mill-driving, but, comparatively speaking, the English manufacturers have lagged behind in its adoption. The developments in the design of textile machinery to suit electric driving have, on the statements of the English makers, been practically confined to their foreign trade. This is not as it should be, and it is hoped that the next few years will see this reproach removed.

Mills and their machinery have, in the past, been designed to meet the conditions imposed by the mechanical drive; that is to say, the rooms and floors have been so placed that a main drive from the engine to each room could be effected with economy and simplicity, and the machines have been grouped, and designed to be grouped, for driving from line shafts. The driving shafts of spinning frames have been run at low speed compared to that of the spindles, because of the engine speed being low, and the increase in speed from engine to spindles has been performed in steps by the intervention of belts and gearing.

The electrical motor, however, is a high-speed machine, and its first cost per horse-power is lessened as the speed is increased.

Textile machinery, then, is likely to undergo a change of design in the direction of an increased speed of the driving shaft, which change of speed should, in spinning machinery, result in an improvement.

In considering the nature of the textile load, we are at first met with the point that a very large proportion of textile machines are required to be run at a constant speed: and it is for this reason that the most suitable type of motor is the alternating current induction motor. This motor has other advantages over the direct current motor, simplicity and lower first cost being the greatest. The adoption of direct current, except in special cases, is to be strongly deprecated.

In dealing with the estimation of the power required to drive textile machinery electrically, and with the annual running cost, the engineer has met with considerable difficulty, owing to the practical difficulty which the mill-owner had in estimating his power other than as indicated horse-power. The variation of the power required by any machine in its operation can only be observed when it is electrically driven, and therefore many false estimates of the number of Board of Trade units which would be consumed have been made. The power costs in a mechanically-driven mill are calculated on the basis of the cost of an indicated horse-power hour, and the load has been assumed to be a steady one, or nearly so. This has led in many cases to a serious overestimation of the cost of the electric drive.

The load on textile machinery is in no case absolutely steady, and in the case of looms and mules is of an extremely variable nature; moreover, the power taken to drive the machines varies throughout the day, and

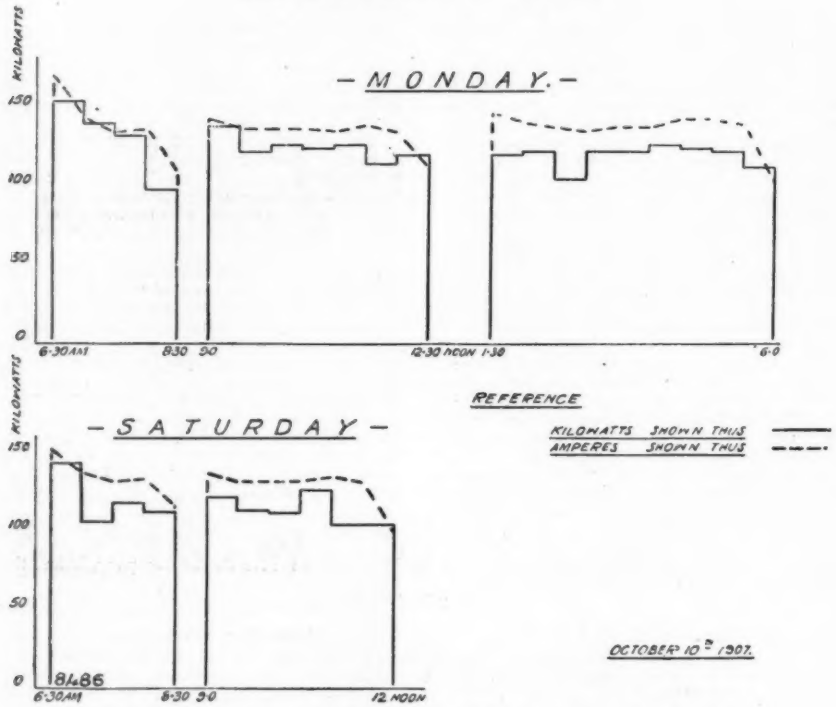


FIG 1.—TYPICAL CURVES, SHOWING VARIATION IN LOAD ON TEXTILE MILL EQUIPMENT.

according to the weather. The accompanying curves exemplify this. Fig. 1 shows the variation of the total power required to drive a mill throughout one day.

Coming to the individual machines, records have been taken electrically of the power required to drive them, and it may be noted here that the taking of such records is a matter of extreme simplicity with the electrical drive: continuous daily records can be taken automatically in every department of a mill. Fig. 2 shows the variation of load on a motor driving a group of twelve looms. Fig. 3 represents the variation of load on a motor driving two mules. The time during which one or both machines were stopped can be clearly seen. The consumption of electricity varies in accordance with the load, and it will be noted that the average consumption is about one-half of the maximum; that is to say, a perfectly steady load of the same horse-power would have consumed twice the number of units. Fig. 4 indicates the variation of load on a motor driving a milling machine, teazer and willey. It is obvious that the energy consumed was extremely small in comparison to the maximum load. With the knowledge gained by such records as these, it is quite easy for the engineer to estimate closely the amount of electricity required per annum to drive any class of machinery. Furthermore, one is frequently able to point out that a certain machine is consuming more power than is consistent with proper working. Faulty adjustment, stiff places, and other faults are in this way very easily detected.

A disadvantage of the collective mechanical driving of various classes of machinery from an engine which is not generally appreciated, is that of the reflection of speed irregularities from one class of machine to another; for example, the variable load due to mules causes a variation of speed not only on the mule countershaft but throughout the whole mill, so that the carding machines or spinning frames in another department suffer a variation of speed which tends to decrease the uniformity and quantity of the rove or thread they produce.

In the individual drive each particular operation is independent of any other.

The first important advantage of the individual drive is the elimination of belts, gearing, and shafting. This represents a considerable

reduction in the power required to drive the machinery. In a number of mills tested by the author, the loss of power in engine and shafting, bearings, belts, &c., amounted to from 30 per cent. to 50 per cent. of the total indicated by the engine.

Tests of various mills have shown that the power taken to drive 100 ft. of shafting, running light, amounts to 1 unit per hour on an average. Belts are equally bad offenders. In a paper before the Bradford Engineering Society read by Mr. H. A. Jones, in 1905, particulars of tests were given showing that with belt driving the loss amounted to 5 per cent. per belt, and with rope driving 6·6 per cent. All these losses of power are difficult to check with the mechanical drive, and they all increase with age. The no-load "friction" card of an engine does not give the true power, as both bearing and belting losses are greater as the load increases, due to the extra pull.

Mill fires have often been attributed to overheated bearings; with the electrical drive the motor ammeter would show an increase of load due to such a cause, and the danger would be removed at once.

Gear losses are considerably more than those of belt or ropes, and when we consider speed records we shall see a further disadvantage. This matter of speed, however, is so important that it will be treated separately.

The second great advantage is in the freedom from limitations as to the position of machines which is imposed by the nature of the mechanical drive. Machines can be arranged with only one object in view, namely, the economical handling of the products of manufacture. Such processes as rag-grinding and willeying can be performed in outlying sheds removed from the main buildings. Washing, dyeing, and milling can be carried on in a position in which the steam and moisture is not conveyed to other parts of the mill. Every odd corner of a site can be utilised.

Furthermore, where the principle of the individual drive is adopted to its fullest extent, viz., a motor to each machine, then each machine is entirely independent of its neighbours, and if stopped is taking no power at all. The effect of stopping and starting a loom in a group is felt by each of the other machines, and produces a variation of speed with a corresponding tearing of the threads and a variation of texture of the material. The cause being removed, a higher maximum speed may be, and is, adopted with safety. A case of interest may be quoted. A group of looms were mechanically driven, the tachograph showing a considerable variation of speed on the countershaft, which ran at 84 revs. per min. On conversion to electrical driving, the speed variation was diminished and the speed of the countershaft raised to 96 revs. per min., without increasing the loom stoppages due to broken ends, &c. The output from the looms was increased in all by 24 per cent.

The removal of shafting and belts admits more light, and removes a principal cause of dust and dirt. The silk manufacturers in Switzerland and Italy consider this a potent reason.

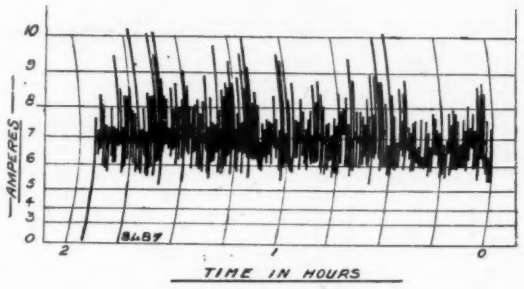


FIG. 2.—LOAD CURVE LOOMS.

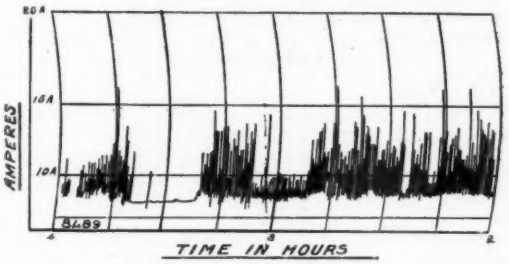


FIG. 3.—LOAD CURVE, MULES.

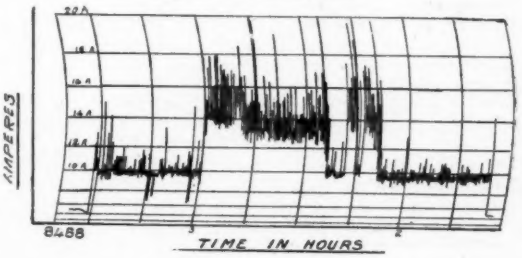


FIG. 4.—LOAD CURVE, MILLING.

NOTE.—*For the illustrations accompanying Mr. T. W. Sheffield's article we are indebted to the Electrical Company, Ltd., Charing Cross Road, W.C.*

Recent Gas Engine Research.

RECENT investigations in connection with gas engine problems, while having for their ultimate object the improvement of the thermal efficiency of this type of prime mover—already well ahead of that of the steam engine—have been in the direction of investigating phenomena concerning which there is still much obscurity, such as the specific heat of gases at high temperatures, flame and explosion waves, wall action in cylinders and flame temperatures.

Dugald Clerk's researches in the latter subject have shown how that an increased indicated thermal efficiency follows from increasing the volume and pressure of the charge while diminishing its temperature and inflammability. Considerable difficulty, however, has hitherto attached to the determination of both the flame and suction temperatures of the charge in the cylinder, and the recent investigations of Profs. Callendar and Dalby in this direction, the results of which are given hereafter, are consequently of importance and interest, although not sufficiently extended to show dependence of suction temperature on *all* conditions of load, speed, gas supply, etc. The second paper, of which a commencement is given hereafter, is by Prof. Lucke, who examines the cycle of operations carried on the cylinder with a view of determining the constancy of effort that is obtainable with a constant external load. The third research to be noted is the third report of the Gas Engine Research Committee, recently presented to the Institution of Mechanical Engineers by Prof. Burstall. As this will be referred to fully later on, it will suffice to mention here that the results obtained do not appear to accord with the usual belief that economy increases with the compression when a suitable mixture is used, but that the cooling action of the cylinder walls affect the result materially.

I.—PROFS. CALLENDAR AND DALBY ON THE MEASUREMENT OF TEMPERATURES IN THE CYLINDER OF A GAS ENGINE.*

1. *Introductory.*—It is important in the experimental investigation of the internal combustion engine to be able to measure directly the temperature of the working fluid at some point of the cycle. If the temperature at a suitable point of the cycle is known, the laws of gases enable us to calculate the temperature at any other point during compression and expansion from the indicator diagram on the assumption that the mass remains constant and that the molecular change occurring in combustion is known. The method usually employed has been to estimate the temperature at the beginning of compression (the temperature at this point is sometimes referred to as the "suction temperature") by computing the total mass of the cylinder contents at this point from a knowledge of the gas and air supply and an estimate of the temperature and mass of the contents of the clearance space. But this is an indirect and troublesome method, and some of the data required are extremely uncertain. Direct measurements of the temperature in the cylinder under working conditions have hitherto failed for various reasons. Professor F. W. Burstall† was the first to employ the platinum thermometer for this purpose. He used wires 0·0025 and 0·0015 in. diameter, and obtained a good deal of valuable information from his experiments, but he did not succeed in measuring the temperature under ordinary working conditions. In his latest report‡ he says:—

"All attempts to use these wires with an engine firing at every second revolution resulted in the destruction of the wire before a sufficient number of observations could be taken. The temperatures have, therefore, been measured on an engine running dead light, that is, firing about one in six of the possible explosions."

These conditions are quite abnormal, and the results from these experiments cannot, therefore, throw much light on the question of the temperatures corresponding to full load conditions.§

Professor B. Hopkinson‖ has recently suggested that the suction temperature might be measured with a wire sufficiently thick to withstand the explosion temperature without melting, and has developed an ingenious method of correcting the indications of a thick wire so as to deduce the

* "Proceedings of the Royal Society."

† *Phil. Mag.*, June, 1895.

‡ "Proc. Inst. Mech. Eng.," October, 1901, p. 1050.

§ The mixtures used were very weak, being 1 of gas to 12 of air, and the correction for radiation error at the maximum temperatures is very large.

‖ *Phil. Mag.*, January, 1907.

temperature of the gas in the cylinder. The method of correction, though somewhat elaborate, appears to have been satisfactory for temperatures up to 300° C., but his final conclusion is as follows :—

"The large size of the wire (namely, 0·004 in.) was chosen because it was intended ultimately to use it for measuring the suction temperature when the engine was working in the ordinary way, taking in and firing a charge of gas. But it was found that even this large wire always fused before any observations could be taken. A still thicker wire might of course have been used for the purpose, but the correction would then have been so great as to make the results valueless."

2. *Method employed by the Authors.*—In order to avoid troublesome and uncertain corrections, it is necessary that the wire employed should be fine enough to follow the changes of temperature of the gas very closely during suction and compression. To employ such a wire in the cylinder under working conditions, it is further necessary that it should be perfectly screened from the flame during explosion. Any apparatus for the introduction and withdrawal of the thermometer must be such as not to make any change in the usual form and extent of the clearance surface during the time interval comprising the end of compression. Otherwise the normal conditions of working would be changed, and a risk of pre-ignition would be introduced. The arrangement used by the authors was designed to satisfy these conditions. The thermometer was contained in a small valve (*T*, Fig. 1), called the thermometer valve, inserted through the spindle of the admission valve *A*, which was bored out to receive it. The admission valve casting *C* is shown detached from the engine cylinder, and the thermometer valve *T* is shown, open to its fullest extent, the maximum lift being 1·5 in. The head *W* of the valve *T* has a seating in the head of the admission valve *A*. The valve *T* is closed by a spring *U*, shown in compression, acting on a nut *N*. The thermometer leads are enclosed in a brass tube *B* fitting inside the spindle of the valve *T*. The tube can be inserted or withdrawn without dismounting the valve. It is held in place by a collar *D*, which is screwed home against the nut *N*. The platinum wires forming the thermometer are seen at *P*. The head *W* of the valve *T* is connected to the tube forming the spindle by the two ribs *R* and *R*, which are made as thin as possible in order to leave the platinum wires freely exposed to the gas when the valve is pushed in.

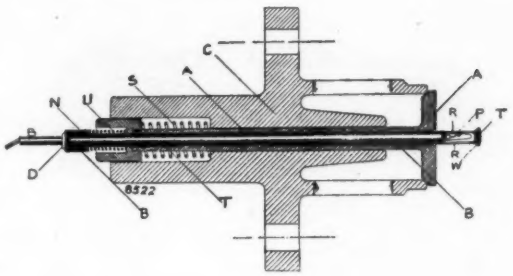


FIG. 1.

Two views of the combined admission and thermometer valves are shown in Figs. 2 and 3, reproduced from photographs, Fig. 2 showing the thermometer valve opened to its fullest extent, and Fig. 3 showing it closed.

The gear for operating the thermometer valve is shown diagrammatically in Fig. 4. A fixed casting *F* carries a shaft *Q*, to which is keyed a long lever *L* and a short lever *l*. The short lever ends in a roller which is held up by a spring against the cam *E*, keyed to the lay-shaft of the engine. The end of the long lever *L* acts on the nut *N* at the end of the thermometer valve *T*, and is forked so as to clear the brass tube *B* of the thermometer. The end of the lever operating the admission valve *A* is similarly forked to clear the thermometer valve *T*. Any desired timing of the exposure of the thermometer valve *T* in the cylinder may be obtained by adjusting the form and position of the cam *E*. In the gas trials described below the thermometer valve was arranged to open during suction, and close towards the end of compression.

3. *The Platinum Thermometers.* — The platinum thermometers and accessory apparatus for observing the temperatures were similar to those employed by Callendar and Nicholson in their experiments on the steam engine, but the thermometers were of somewhat simpler construction, since they were not required to be exposed to high pressures or temperatures. The leads were a pair of twin wires, insulated with rubber and cotton, and were fixed gas-tight in the brass containing tube. The projecting ends of the copper leads were held in place with mica washers. A loop of platinum wire, 0·001 in. in diameter and 1 in. long, was soldered to the ends of the thermometer leads. The ends of the compensator leads were similarly connected by a loop of the

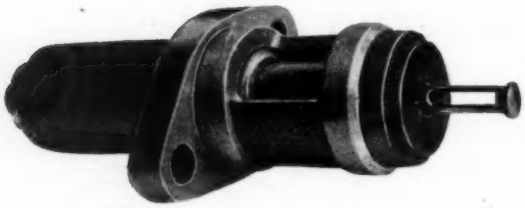


FIG. 2.

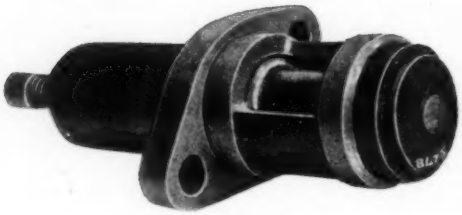


FIG. 3.

same wire, $\frac{3}{8}$ in. long. The thermometer and compensator were connected to opposite sides of the Wheatstone bridge, so that the bridge reading gave the difference of resistance between them, corresponding to the resistance of the middle $\frac{3}{8}$ in. of the thermometer loop. This provision of a compensating loop has often been overlooked, but is most essential when using short loops of fine wire for the measurement of rapidly-varying temperatures. The ends of the fine wire loops close to the leads are affected by conduction of heat to or from the leads,

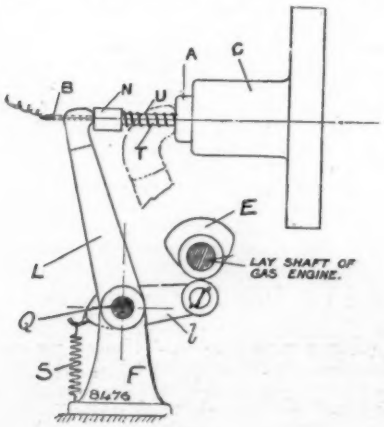


FIG. 4.

and cannot follow the rapid variations of temperature; but the end effect is eliminated by observing the difference between two loops of different lengths. The lengths of the loops were chosen so as to give with the wire actually employed a change of resistance of 1 ohm approximately for 100° C. Shorter lengths might have been employed without material reduction of sensitiveness; but the above lengths were found to be sufficiently stiff to stand the commotion in the cylinder satisfactorily for long periods. After each run the thermometer was removed and placed in a tube in a vessel of water. Its resistance was then measured at the temperature of the laboratory, in order to test for variations of the zero. It was found that the zero was generally raised after a run of half-an-hour or so by about $\frac{1}{5}$° C., owing to slight strain or distortion of the wire; but it was easy to take account of these small changes, which would not, if neglected, however, have materially affected the accuracy of the measurements. The current employed in measuring the resistance was about $\frac{1}{100}$ part of an ampere. The heating effect of this current on the thermometer was measured, and found to be less than $\frac{1}{4}$° C. The same current was employed in determining the fundamental interval of the thermometers. The heating effect could be safely neglected, as it was nearly constant, and would not produce an error greater than $\frac{1}{20}$° C. Owing to slight changes in temperature from stroke to stroke during the working of the gas engine, the mean temperature at any part of the cycle could rarely be observed with an approximation closer than 1°. As the temperatures to be observed were about 100° C., no great refinements in testing the wire were required.

4. *The Periodic Contact-Maker and the Electrical Connections.*—In order to observe the temperature at a definite point in the cycle, a periodic contact-maker was inserted, either in the galvanometer or in the battery circuit, and was set to close the circuit at the desired point. In this method errors may arise from thermo-electric or induction effects. Both effects were practically negligible with the apparatus employed, but the thermo-electric effects were rather larger and more variable than the induction

effects. The periodic contact was therefore usually connected in the battery circuit, so as to eliminate the thermo-electric effects. The electrical connections, including the periodic contact-maker, are shown in Fig. 5, opposite. In this diagram PS, QS are the equal ratio arms of the Wheatstone bridge. The galvanometer G is connected to the point S and to the sliding contact on the bridge wire BW. The thermometer and its leads P^1 are connected on one side of the bridge-wire, and the compensator C and the balancing resistance R on the other. The battery circuit includes a mercury reversing key K, an adjustable resistance r, and a storage cell V; and the battery is connected to the bridge at the points P and Q, and to the brushes of the periodic contact-maker at E. The brushes E are carried by an insulated arm A bolted to a divided disc O riding loosely on the lay-shaft of the engine, and capable of being clamped in any position by the screw L. The index I shows the crank angle corresponding to the middle point of the contact when the insulated copper strip D carried in the fibre bush F passes under the brushes.

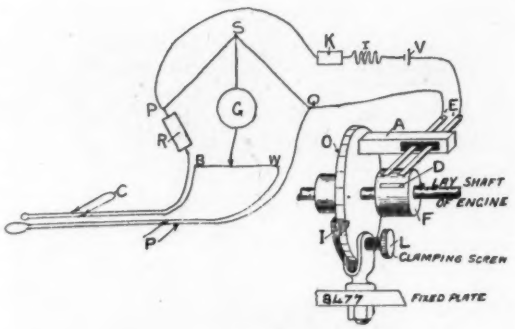


FIG. 5.

5. *Percussion Contact-Maker.*—The common form of wipe contact maker, illustrated in Fig. 5, was employed in the earlier experiments, but was found to possess certain disadvantages. The contact was difficult to keep clean, and the timing was liable to vary with speed and wear. The duration of contact could not be readily adjusted or accurately verified. In the later experiments a novel form of contact was adopted which appeared to be free from these defects. The construction of this contact-maker is illustrated in Fig. 6. A brass bush B keyed to the lay-shaft of the engine carries two fibre washers or cams W_1 and W_2, which can be clamped in any relative angular position against the flange of the bush by the nut N. A radial step, as w_1, is made in each washer, and the surface gradually rises from the bottom of the step to the normal circular surface of the washer. The brushes of the wipe-contact are replaced by stiff springs S_1 and S_2, the reflexed ends of which rest on the fibre cams. A projection Z carrying a platinum-pointed screw p is riveted to one of the springs, and the screw p is adjusted so that its point is just clear of the platinum rivet i in the other spring, when both springs are riding on the circular surfaces of their respective cams. Contact is made when the rotation of the lay-shaft in the direction of the arrow brings the radial step w_1 of the cam W_1 under the spring S_1, thereby allowing it to fall down the step, thus bringing p and i together. Contact is broken when the radial step w_2 of the cam W_2 reaches the spring S_2, thereby allowing the second spring to fall down the step w_2. The epoch and duration of contact are readily adjusted by adjusting the angular positions of the cams relatively to the bush and also with regard to one another. The distances between the springs and the platinum

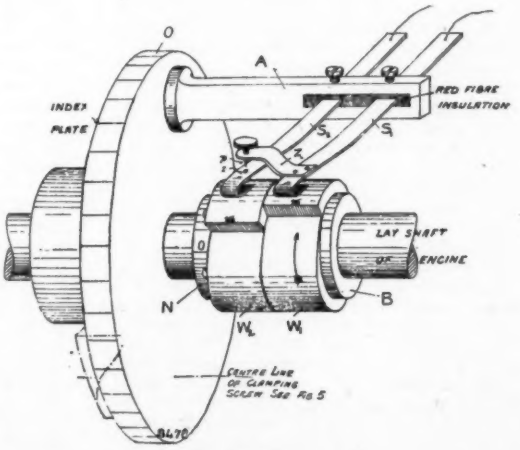


FIG. 6.

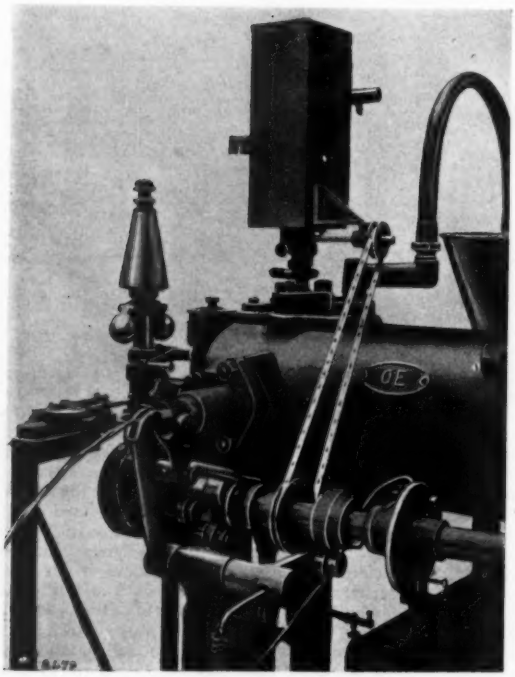


FIG. 7.

contacts and the steps w_1 and w_2 are exaggerated in the diagram in order to make the principle of the apparatus clear. The percussion form of contact with platinum points was found to give more definite and certain results than the wipe pattern. It always kept itself clean, and no trouble of any kind was experienced with it. The duration of contact was generally adjusted to correspond with 20 degs. of the crank-angle, or one-thirty-sixth part of a revolution of the lay-shaft.

6. *General Arrangement of the Engine.*— The only engine immediately available for the purposes of the tests was a 10-h.p. "Crossley," forming part of the laboratory equipment of the Central Technical College, with a cylinder 7-in. bore and 14-in. stroke, the compression ratio being 4·68. It was not quite the latest pattern, but was in very good condition, and well suited for testing the application of the method. It had porcelain tube ignition. It was directly connected to a four-pole dynamo of 8 k.w. capacity, mounted on the same shaft. This arrangement was particularly advantageous, as it permitted the engine to be run under widely-varying conditions of speed and load. For measuring temperatures by the periodic contact method, it is most important that the cycle of operations should be perfectly regular, and that there should be no missed explosions; otherwise it is impossible to take readings accurately, owing to the wide variations of temperature from stroke to stroke. With this object, the governor was disconnected, and the gas-admission valve arranged to open at every suction stroke. The field of the dynamo was separately excited, and the load taken by adjustable wire resistances, so that the engine could be made to run quite steadily at low speeds if desired. By a slight alteration in the electrical connections it was possible to supply the dynamo with current from the external lighting system, and employ it to drive the engine. This was required in some trials made for the purpose of testing the sensitiveness of the thermometers.

7. *Indicator Diagrams.* — When running the engine with rich mixtures, the rapidity of the explosion was so great that satisfactory diagrams could not be obtained with the ordinary piston type of indicator. The sudden rise of pressure caused violent oscillations of the pencil, which continued throughout the stroke and made accurate readings impossible. For this reason, an optical indicator, or "manograph," of the "Carpentier" type was employed, with some modifications suggested by previous experience. In this instrument the pressure acts upon a steel disc or diaphragm, the movement of which is transmitted to a short optical lever, which carries a mirror reflecting a spot of light on to a photographic plate. The lever is pivoted on a fixed point, and has a second arm at right angles to the first, which simultaneously receives a movement corresponding with the movement of the piston. This manograph was originally intended for taking diagrams from small high-speed motors with closed crank-chambers. It was supplied with a long, fine, copper tube for connecting the disc-chamber to the cylinder, and with a long flexible coupling to be attached to the crank-shaft, the rotation of which was made to reproduce the motion of the piston by

means of a small crank actuating the arm of the optical lever. In adapting the manograph to the gas-engine, we found it more convenient to dispense with these connections, which were a source of inaccuracy. The disc-chamber was screwed directly on to the indicator cock of the engine. In the earlier experiments the piston motion was obtained from a sprocket wheel on the lay shaft, but later it was reproduced directly by means of a lever driven by a cord attached to the usual indicator rig connected to the piston of the gas-engine. Fig. 7 shows the optical indicator in place, and also the sprocket-wheel and band driving from the lay-shaft. The figure shows incidentally also the general arrangement of the gear for working the admission and the thermometer valves, and the disc and contact-maker on the lay-shaft, the details of which have already been illustrated diagrammatically in Figs. 4 and 5.

As the scale given by a plane disc is not one of equal parts and is liable to vary slightly with slight differences in the clamping of the disc, the scale of the indicator was calibrated on each occasion in its actual position on the engine. A gas-bottle and a standard pressure-gauge were connected to the blow-through hole of the indicator cock, and lines were traced on the photographic plate corresponding to equal intervals of pressure, and also lines at right angles to these corresponding to equal displacements of the piston. By using a grill prepared in this manner for measuring the diagrams, errors due to the variation of the pressure scale, or inaccuracy in the reproduction of the piston motion, are practically eliminated. By using discs of different thicknesses, or by different combinations of discs, a considerable range of pressure could be covered with satisfactory accuracy. For the lower pressures, and for the tests in which the engine was driven by the electric motor without firing, a steam-engine indicator of the "Crosby" pattern was also employed. This indicator was calibrated by weights placed upon a revolving plunger of known area, and was found to be correct, and to agree with the optical indicator in those tests in which diagrams were taken with both instruments.

8. *Testing the Platinum Thermometers for Lag.*—It was well known from previous experiments that a platinum wire 0·001 in. in diameter was capable of following the cyclical variation of temperature of a gas during suction and compression with sufficient accuracy for the determination of the suction temperature, but it appeared desirable to measure the lag of the thermometer at various speeds under these conditions, and to test whether a thermometer inserted in the manner already described could be relied upon to give the average temperature of the mixture in the cylinder, and how far its readings might be affected by the temperature of the valve in which it was enclosed. For this purpose the engine was driven by a motor, compressing and expanding a charge of air without firing. Temperature readings were taken throughout the cycle for comparison with the mean temperatures deduced from the indicator diagrams.

Two thermometers were employed which differed slightly in the disposition of the platinum loop. In the first, designated Pt_1, the fine loop was attached in the usual manner, projecting beyond the ends of the leads. In the second, designated Pt_2, the copper leads were made somewhat longer, and the platinum loop was inverted so as to lie between the leads. It was thought that with this latter method of construction the fine wire loop would be better protected from accidental damage in inserting or withdrawing the thermometer, and would be better able to withstand the shock of opening or closing the thermometer valve. This proved, in fact, to be the case. It was found, however, that the projecting loop Pt_1 suffered very little distortion, and that although the thermometers agreed very well on the readings of the suction temperature, the readings of Pt_2 were appreciably affected by the close proximity of the leads to the fine wire, when the difference of temperature between the leads and the surrounding gas was considerable.

Two kinds of motor-driven tests were made. In the first kind the gas-cock was shut, and the valves were worked in the usual way, so that a fresh charge of air was taken in and compressed during each cycle. In the second kind the gas-cock was shut, the valve-levers were removed, and the thermometer-valve was fixed permanently open, with the gas-admission valve permanently closed, and the tension of the exhaust-valve spring was relaxed, so as to allow it to act as a non-return valve for admitting a little air to the cylinder to compensate for leakage at the end of each suction stroke. Under these conditions the piston expands and compresses a practically constant charge of air at each revolution, and there is little or no disturbance due to the opening and closing of valves. This made it possible to secure a more accurate comparison of the thermometer with the indicated temperatures throughout the cycle, and to obtain a more satisfactory estimate of the

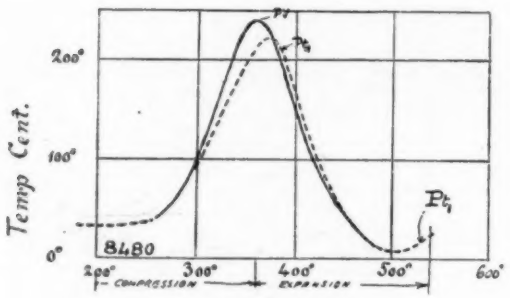


FIG. 8.

lag. With the valves opening and closing in the ordinary way the cycle occupies two revolutions, and the readings of the thermometer from stroke to stroke are appreciably disturbed by slight variations in the opening and closing of the valves. Moreover, the mass of air contained in the cylinder is constant only for a part of each alternate revolution, so that the comparison with the indicator cannot be extended satisfactorily throughout the cycle.

9. *Comparison of the Temperatures recorded by the Thermometer with the Temperatures calculated from the Indicator-Diagram.*—The comparison in the case of the first method of working—namely, valves opening and closing in the usual way—is made in Fig. 8, above. The broken line represents the reading of the platinum thermometer Pt_1 in degrees Centigrade, plotted with reference to crank angle during the compression and expansion strokes. The full line represents the temperatures deduced from the corresponding indicator diagram by calculating the product PV for the period during which the mass of air enclosed remained sensibly constant. The average speed in this trial was 102 revs. per min. An appreciable leakage or loss of heat takes place during the period of maximum compression, so that the compression and expansion curves are not exactly superposed on the card, but each is sensibly adiabatic, following the law $PV^{1.4} =$ a constant within the limits of error of the pressure measurements. It would make very little difference to the form of the curve between 260 degs. and 460 degs. of crank angle if the temperatures at each point were calculated from the pressures alone (instead of from the product PV), assuming the adiabatic law $\theta^{1.4}/p^{0.4} =$ a constant. The temperatures on the PV curve are calculated on the assumption that the mean temperature of the charge is given correctly by the platinum thermometer at 206 deg. of crank angle. It will be observed that the Pt curve is not quite symmetrical with the PV curve, the lag appearing greater during compression than during expansion. This may have been caused by some peculiarity in the direction of the currents of air in the cylinder with reference to the position of the ribs of the thermometer valve during compression. The thermometer valve was fixed in this experiment with one of the ribs vertically over the other, so that the opening through the valve might be horizontal or parallel to the axis of the cylinder. During expansion, when the turbulent motion of the air due to admission had subsided, the motion is probably parallel to the axis of the cylinder, and the lag of the thermometer is seen to be very small. The PV and Pt curves reunite towards the end of expansion. It was observed in another experiment that the effect of turning the thermometer-valve through a right angle, so that the ribs should not obstruct the air current, was to raise the maximum indication 10° C. The reading at the lowest point corresponding with the suction temperature was not appreciably affected by the position of the thermometer-valve. In a repetition of this test, with the thermometer Pt_2 having the inverted loop, it was found that the close proximity of the copper leads to the fine wire raised the readings of the suction temperature 2° to 3° C. and lowered the reading of the maximum temperature nearly 20° C. It may be inferred from this test that a thermometer of the type Pt_1 with a projecting loop may be trusted to give the suction temperature with an approximation of 1° C., in spite of the presence of the enclosing valve, providing that the temperature of the valve does not differ greatly from that of the mixture in the cylinder. When the temperature is changing most rapidly, and the temperature of the valve differs nearly 200 degs. from that of the air, the thermometer lags only 20 degs., and a change in the position of the ribs of the thermometer-valve does not affect the readings by more than 10° C.

The comparison in the case of the second method of working, in which the valves are continuously closed, is illustrated in Fig. 9. This method promised to afford a more accurate method of testing the thermometer owing to the greater steadiness of the conditions, which permitted more accurate readings of the temperature. Some

unexpected difficulties were encountered owing to the presence of small quantities of water, resulting from the formation of fog; but the observations were in many respects instructive, and may be worth recording as additional evidence. The quantity of water required to saturate the clearance space at a temperature of 100° C. was only 0·003 lb. Nearly half of this quantity was found to have accumulated in some of the experiments, which afforded an interesting study in the adiabatics of fog. The effect of the formation of fog is very greatly to reduce the range of temperature for a given range of pressure, and the presence of water must, therefore, be carefully avoided in this method of testing a platinum thermometer. In the test reproduced in Fig. 9, the air in the cylinder was sufficiently dry for the calculation of the temperatures from the card by the *PV* method. The compression and the expansion curves were very nearly symmetrical and adiabatic. The motion of the air in the cylinder was parallel to the axis in both, and the *PV* and *Pt* curves were approximately symmetrical. The lag was greater than in Fig. 8, partly owing to the higher speed (130 revs. per min.), but partly also due to the more quiescent state of the air in the cylinder. The range of temperature with Pt_1 was from − 6 degs. to + 159° C., as against − 10 degs. to + 173° C., calculated from the card. It must be remembered, however, that there was probably a snow fog in the cylinder at − 10 deg., which throws some doubt on the accuracy of the *PV* curve, and would account for part of the lag of the thermometer owing to condensation on the wire. Also that an error of $\frac{1}{1000}$ in. in measuring the card would make an error of 1 deg. of temperature in the *PV* curve at this point. The range given by the inverted loop thermometer Pt_2 in this test was from 0° C. to 142° C., being reduced by the proximity of the wire leads, the temperature of which was approximately 50° C. The experiment was repeated with and without the thermometer-valve in place. The presence of the valve lowered the reading of the platinum thermometer about 10° C. at the point of maximum temperature when the ribs were placed in the horizontal plane, so as to obstruct the flow of the air through the aperture, but it did not make any appreciable difference when the aperture was horizontal.

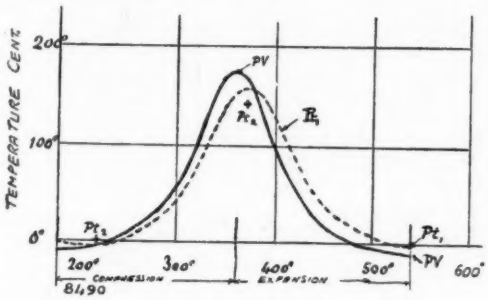


FIG. 9.

10. *Suction Temperature in Gas Trials.*—A number of trials were run under various conditions of speed and load, and gas supply, with the engine driving the dynamo in the ordinary way. For these trials the thermometer-valve was adjusted to open about the middle of the suction stroke, and close soon after the middle of the compression stroke. The temperatures were observed at the end of the suction stroke, and just after the closing of the admission valve. An observation was also taken at the end of the compression stroke, when the thermometer-valve was closed in order to give the temperature of the valve itself. The suction temperature was found to vary with the conditions of running from about 95° C. on light-load trials to about 125° C. at maximum load, the air temperature being in all cases nearly 20° C., and the jacket temperature 27° C. It should be remembered that in all these trials an explosion occurred at every second revolution—that is, there were no misses, the governor being entirely cut out. The trials were not, however, sufficiently extended to show the dependence of the suction temperature on the various conditions of load and speed and gas supply and jacket temperature. For the present the authors must content themselves with giving an illustration of the method of calculation they propose, reserving further discussion until more complete data are available.

The most interesting of the trials from a theoretical point of view are those with rich mixtures, in which combustion is practically complete at constant volume, and the diagram conforms most closely to the theoretical type. A typical example is shown in Fig. 10, taken from trial 26, photograph 62. Six consecutive explosions, photographed on the same plate, were practically identical. The following are the data of this trial:—

Revolutions per min. 130.

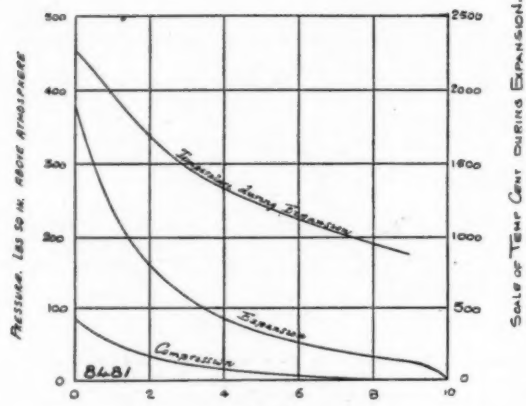


FIG. 10.

Ratio of gas to air, 1 to 7·1.

Atmospheric temperature, 20° C.; jacket temperature, 27° C.

Temperature of thermometer valve at 360 degs. crank angle, 122° C.

Temperature of mixture in cylinder at 260 degs. crank angle, 111° C.

Pressure in lbs. per sq. in. absolute at 260 degs. crank angle, 18·5.

Volume of mixture at 260 degs. crank angle, 0·2846 cubic ft.

In calculating the temperatures along the expansion line, it is assumed that combustion is complete, and that the gases have undergone a molecular contraction, depending upon the richness of the mixture and the composition of the gas, which in this case amounts to 4·3 per cent. To find the temperature at any point in the expansion curve it is only necessary to divide the product of the pressure and volume at that point by the constant 0·01315, representing the observed value of the product pv/T at the point corresponding to 260 degs. crank angle λ, corrected for contraction. The resulting curve of temperature is shown in the upper part of the diagram (Fig. 1c). The temperature thus calculated is the apparent or effective temperature, and includes the effect, if any, of dissociation. By comparing and analysing such curves it may be possible to deduce important relations bearing on the phenomena of combustion of gaseous mixtures. The curve shown in the diagram exhibits a marked change of curvature at 0·4 of the stroke, and becomes nearly straight. A peculiarity of this kind might be due to some imperfection of the indicator, but it might also imply a further stage in the combustion. Without an exact knowledge of the suction temperature it would be impossible to investigate such points satisfactorily.

By a curious coincidence a diagram taken in another trial, Fig. 11, trial 4, photograph 9, with a different ratio of gas to air—namely 1 to 5·8—gave a practically identical expansion curve, not differing by more than 1 lb. at any point from the curve of the preceding example recorded on photograph 62. The mean pressures deduced from the brake horse-power were also very nearly identical. Without a knowledge of the suction temperature it might be inferred that the two trials were really identical, and that some mistake had been made in the gas measurements. The data for this trial are as follow:—

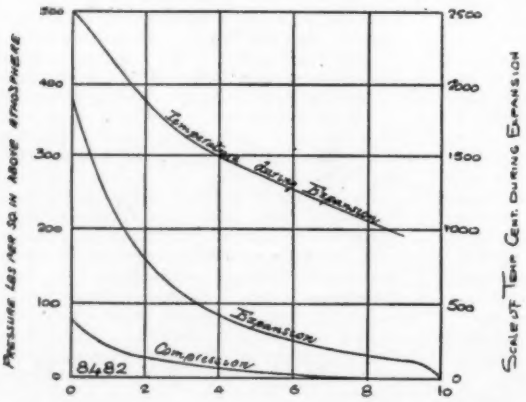


FIG. 11.

Revolutions per min., 114.

Ratio of gas to air, 1 to 5·8.

Atmospheric temperature, 21° C. Jacket temperature, 27° C.

Temperature of mixture at 260 degs. crank angle, 130° C.; and pressure 17·8 lb. per sq. in. absolute.

Molecular contraction on combustion, 5·1 per cent.

The constant for calculating the temperature along the expansion curve comes out 0·01195 in place of 0·01315, and the temperatures are all much higher, as they should be with a richer mixture. The temperature curve in Fig. 11 shows the same curious anomaly as that from photograph 62 in Fig. 10, although the diagram was taken with a different disc having a different pressure scale, and with an entirely different arrangement of indicator gear, the piston motion being transmitted from the lay-shaft in the way shown in Fig. 7, instead of being taken direct from the usual indicator rig as was the case in experiment 26.

11. *Conclusions.*—It appears probable from these experiments that the temperature of the thermometer-valve never differs very much from the temperature of the gases shortly after the closing of the admission-valve in the method of construction adopted by the authors, in which the thermometer-valve is inserted through the spindle of the admission valve. In a specially-designed gas-engine, a separate opening might be provided for the insertion of the thermometer, but it is probable that the temperature of the valve in this case would not be so nearly equal to the suction temperature to be measured. The method adopted by the authors has the advantage that it can be applied without difficulty to any existing engine by simply making a special admission-valve. Since the temperature of the thermometer-valve in this method of construction differs so little from the suction temperature at the required point, it appears probable that the thermometer gives the actual suction temperature required with an approximation of the order of 1° C. The temperature at this point can probably be measured with a fine wire with a greater degree of accuracy than the pressure. In order to obtain the pressure at this point, it is necessary to take a diagram with a light spring in the indicator, as the pressure cannot be satisfactorily measured with a spring strong enough to record the explosion temperature. Further, it is absolutely necessary in these investigations that the engine should repeat a perfectly regular cycle at each explosion. No results of any value can be obtained with a hit-and-miss governor in operation, because the conditions vary too greatly from stroke to stroke. This has been repeatedly shown by previous trials. In measuring the expansion and exhaust temperatures by a similar method, it would be most appropriate, so far as the temperatures to be measured are concerned, to insert the thermometer-valve through the spindle of the exhaust-valve.

The authors desire to record their obligation to Mr. Witchell and Mr. Betterley, and to other members of the laboratory staff, for the able assistance they severally gave during the investigation.

II.—PROF. C. E. LUCKE ON THE CONTROL OF INTERNAL COMBUSTION ENGINES.*

One of the primary prerequisites for close engine control or regulation, be that engine

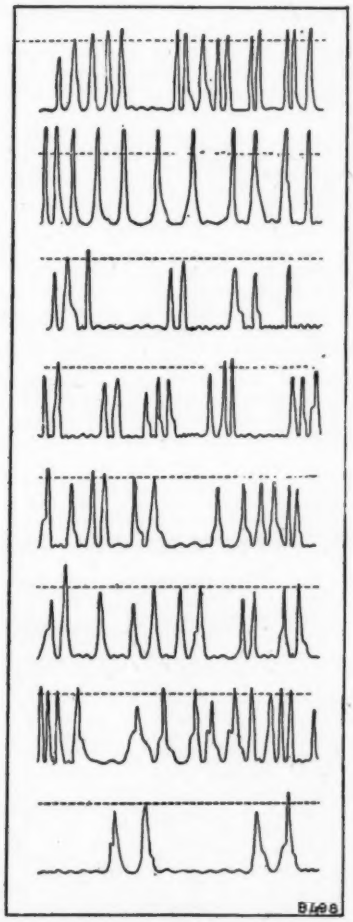


FIG. 12.—SHOWING VARIATIONS IN MAXIMUM PRESSURE.

* Abstract of paper read before the American Society of Mechanical Engineers.

a steam engine, a gas engine or any other kind of motor, is absolute constancy of cyclic effort with a fixed position of the controlling mechanism. The promptness with which a change of effort will follow a change of setting of the governing or regulating gear depends among other things upon the cycle of operations to be carried out in the cylinder, and, in the case of gas engines, the cycle is such that much time may elapse between a governor movement and the controlling effect desired. This has been clearly pointed out in many papers, and as ordinarily called "cyclic influence" it is well understood.

It is the object of this paper to examine into the conditions under which constancy of effort may or may not be obtained with constancy of setting of the governor and valve gear. It is possible in gas engines to get many different indicator cards at apparently constant external load, the differences indicating differences of effort, and in most gas engines, even with the mechanism for controlling the engine fixed in position, the same variation of indicated effect may be observed. The differences which will appear on the indicator card for apparently identical conditions are not differences in compression, suction or exhaust lines, but almost entirely differences of combustion and expansion lines, or as the expansion line position is fixed by the combustion line, it may be said that the differences are due entirely to variations in combustion lines.

It would appear, therefore, that because combustion lines in gas engines are not identical for apparently identical conditions of the mechanism that we have failed to control this combustion in a manner required by everyday practice in the use and application of gas engines. Whether, however, this failure is due to ignorance on the part of designers, or whether the end sought is in opposition to natural phenomena, will not appear without analysis.

As an illustration of some of these variations Fig. 12 is presented on p. 103, and represents a continuous record of the maximum pressure over several strokes in a small gasoline engine governing by holding the exhaust valve open when the load is light, each line giving the results of one constant adjustment. Aside from the variations produced by the idle strokes, which are, of course, not here considered, it is to be noted that the maximum pressures for any one adjustment which should be identical are not identical, and that in some cases they are more clearly identical than in others.

(*To be continued.*)

A Dynamical Method of determining Experimentally the Specific Heat under Constant Pressure of Superheated Steam.

At a recent meeting of the Transvaal Institute of Mechanical Engineers, Mr. Sydney B. Bilbrough, B.A., replied to the discussion of his paper detailing the results of his research in the determination of the specific heat of superheated steam. Mr. Bilbrough's original paper will be found in THE ENGINEERING REVIEW, vol. XVI., pp. 104 to 124, and Mr. R. H. Smith's reply thereto contributed exclusively to this Journal on pp. 161 to 165.

Reply to Discussion.—In the first place the author desires to express his high appreciation and thanks for the honour conferred upon him by this Institute, in that they have thought fit to award him the Gold Medal of the year for the above paper. It is a decided encouragement to the carrying out of research work, especially in a private capacity, work which is proverbially known to carry no reward, except the satisfaction and delight of attaining what one is looking for.

I must also thank those who have

contributed to discussion, though only three have done so—viz., Professor R. H. Smith and Messrs. Ostreicher and Laschinger. They have gone deeply into the subject, and wandered through difficult and obscure paths. It is well known that for a full comprehension of physical experiments or their description it is almost essential to conduct the experiments personally, for no amount of descriptive reading can convey so true an idea as the actual experiments. It is almost to be expected, then, that some of the criticism should be due to an incomplete grasp of the method of experimenting and the applied theory.

A small boiler heated by blow-lamps has been objected to on the ground that the rate of flow, to be uniform, requires a large reservoir of steam behind. But the rate of flow is constant if the pressure remains constant, even though the boiler be as small as a thimble, and the pressure did remain constant for each experiment. The experiments were first tried on 200 h.p. boilers at the Crown Deep and Village Main Reef, but were abandoned because the conditions of superheat and pressure were not so completely under control as with the small boiler and paraffin lamps used.

On free expansion of a gas or a vapour, it is not the intrinsic energy that necessarily remains constant, but the intrinsic energy plus work done, and this constitutes total heat. I do not ask anyone to believe this proposition because I say it, but because authorities* in the past have already proved it, and I gave references to three.

Mr. Ostreicher, in his contribution, says that the dotted curve of no variation in Professor Smith's contribution reveals to him "an inherent error either in the experimenting or in the formula employed." This is a serious indictment, so let us examine it closely.

He then regards ·305 as the specific heat of saturated steam to prove his contention. But here, fundamentally, he is wrong, for there is no specific heat of saturated steam *at constant pressure*. In his definition he omits the constant pressure. If the pressure be kept constant, and heat be added to saturated steam, it at once becomes superheated. And if heat be abstracted at constant pressure it condenses without cooling. You cannot raise or lower the temperature of saturated steam if the pressure is constant. Hence there is no analogy on this basis between the figure ·305 for saturated steam, which is for a varying pressure, and K or C_p for superheated steam, which is at constant pressure.

His remarks on wet steam, saturated steam, and water in the superheated steam, also the remarkable affinity of alcohol for water, though extremely interesting, do not quite apply to these experiments on account of the method employed.

To all other throttling experiments this standard condition of dry saturated steam applies very forcibly. But herein lies the accuracy of this method of using only one thermometer and varying the pressure, on the atmospheric side of the throttling disc. The condition of the steam entering the disc, whether wet, dry or superheated, is entirely eliminated.

Indeed, for most of the experiments of low superheat, the steam used would invariably be wet on the boiler side of the disc. Mr. Ostreicher admits that the moisture is evaporated immediately on passing the throttle, and I agree with him, and this is all that is required for the experiments.

The high results obtained near saturation have drawn criticism from everybody, and rightly so, for the results are most extraordinary. The author only published them because they were based on experimental figures of a very decided nature. They were the easiest to carry out, and duplicated each other better than any others. The very sharp rise of the specific heat curve at about 1 degree superheat looked very suspicious, and yet all the experimental points lie exactly on the curve. The explanation of moisture entrained in the steam round the thermometer has never been satisfactory, and at best is only a guess.

Addidendum.—I will now proceed to offer another explanation of these particular figures of high specific heat near saturation. All critics have failed so far to see this point, and I only discovered it myself after replying to Professor Smith's critique. It is not due to entrained moisture from the boiler.

You will remember that the radiation experiments showed a drop in temperature of about 10° C. over a distance of 12 in. of the calorimeter. Also the thermometer bulb lay in the direction of the moving steam, and not across it. The length of the thermometer bulb was 1¼ in. There must, therefore, be a distinct difference in temperature between the top of the bulb and the bottom, and the reading will be the temperature of the middle or the average of the extremes. This is all right when the superheat is considerable, and true

* Clerk Maxwell, "Theory of Heat," p. 209.

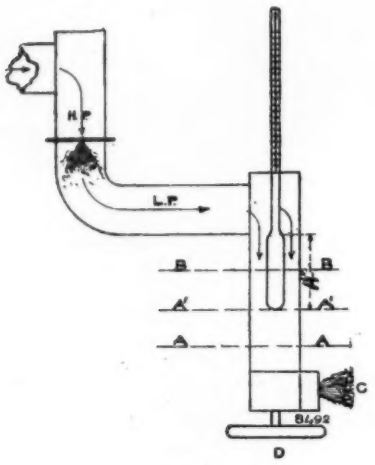


FIG. 1.

results are then obtained. But as we reduce the superheat to within a degree of the saturation point, it is obvious that the bottom of the thermometer will be in the already saturated steam, and yet the thermometer itself be registering a slight degree of superheat.

Referring to the figure. Suppose the steam is flowing steadily through the calorimeter, and the thermometer is registering 1° F. superheat, this is the temperature of the steam at the line BB, so that $(T-t) = 1°$. At some line AA, a small distance further on, the 1 degree of superheat will have vanished, due to radiation, and all below AA is saturated steam at temperature t, getting wetter as it advances to the exit C, due to radiation loss.

Now, suppose we raise the pressure in the chamber by slightly closing the exit valve D. By raising the pressure we reduce the superheat, because the saturation temperature t of the steam is raised. So the saturation line AA will advance towards the thermometer and take up the position at A^1A^1 and temperature t^1. But the thermometer will still register a slight superheat $(T-t^1)$. If the pressure is raised still further, the saturation temperature t^1 will increase to correspond with increase of pressure, and the thermometer will rise in temperature. This rise in the thermometer is then not due to deviation from Joule's law, but is simply due to the rise in the saturation temperature at the bottom of the thermometer. Those who have followed the reasoning of the experiments will see that the highest value obtained for K, namely, 10 at the saturation line, should really be, on this basis, infinity, because the saturation line AA will have enveloped all the thermometer bulb, and any change in the temperature of the thermometer is simply due to a change in the saturation temperature t.

Or in the equation

$$K = \frac{\cdot 305\,(t_2 - t_1)}{(t_2 - t_1) - (T_2 - T_1)} \qquad (8)$$

at the saturation line $(T_2 - T_1) = (t_2 - t_1)$

$\therefore \quad K =$ infinity.

Hence the results obtained with a superheat so small that the saturation temperature has reached the line A^1A^1, do not represent the deviation from Joule's law nor the specific heat of the superheated steam.

I have carefully estimated that the drop in temperature due to radiation loss over the length of the thermometer $1\frac{1}{4}$ in. for Tables VIII. and IX. is about ·6° F. So to make sure, we reject all results with 1·0° F. superheat or less.

This, of course, is only over a very small range, and in no way affects the results beyond that. The specific heat with 1° F. of superheat is really of academic interest only. Nevertheless, the original figures over this 1 degree were of such a peculiar nature, and confirmed each other so well by experiment that I did not feel justified in withholding any of them, and now that we have the real explanation, we are the wiser for it.

What are the new values for Q and Y? By producing the curves in Fig. 4 (vol. XVI., p. 116) and Fig. 3 (vol. XVI., p. 110), and neglecting the experimental figures from 1° F. superheat to saturation, we get

$Q = 12{\cdot}5$ instead of 16·4.

and $Y = Q \times {\cdot}305 = 3{\cdot}8$ instead of 5·0.

The value for Q or Y at high pressures is so small that I have made no change in them. Also the rate of flow (Table XI.) was very much greater, so there is no data to determine the radiation loss for this increased flow, but it would be less than for the experiments in Tables VIII. and IX.

Hence the chief bone of contention and disagreement is withdrawn from the contest. Observe, too, that the explanation "water in the steam" is more or less correct; but how very different from what was first thought to be the explanation! The saturation does not come over as entrained moisture, but rises from the bottom or exit end of the calorimeter. And again, the

high values supposed to represent K or Cp were not due to evaporation of this moisture, but simply to the change in saturation temperature due to the change of pressure.

It is also easily seen why the tests duplicated so well the nearer we approached saturation. If it were all saturated steam, they would duplicate perfectly, for this is a standard method of graduating a thermometer—viz., by saturated vapour pressures.

The figures near saturation which involve the most experimental work and give the most trouble in their theory, are really of a secondary importance, compared to the fact that, beyond 16° F. superheat, Joule's law is strictly obeyed. This is the backbone of the paper, but it is also of importance to know the degree of superheat where the steam deviates from Joule's law —viz., 16° F. at atmospheric pressure, and 3·5° F. at 150 lbs. per sq. in.

One more point. Are Regnault's experiments accurate enough to allow us to deduce the specific heat from Joule's law? Professor H. L. Callendar* says: "It is unlikely that the order of accuracy attained in his (Regnault's) experiments was greater than one-half of 1 per cent. at any point."

Now the error in the differential coefficient dH/dt is usually taken at about 16 times the error in total heat. Hence Regnault's experimental error for dH/dt is $16 \times \frac{1}{2}$, or, say, 8 per cent.

I cannot agree with Mr. A. H. Peake,† in discussing his own throttling experiments, that this error is too large, and for the following reason:—

Taking the exhaustive experimental results obtained by Knoblauch and Jakob, in which they determine most elaborately the specific heat by the direct method, we find that for over 100 lbs. per sq. in. pressure and fairly high degrees of superheat, the value for K which they obtain is about 0·55. In Table XIII. of this paper, using Regnault's figure for saturated steam, we get ·31.

Hence if Regnault's figures are to be so altered as to suit the value ·55 for K, it means that his experimental error for dH/dt should be as great as 77 per cent., and not only 8 per cent.

In other words, Regnault's experiments must be shown to have 10 times their present estimated error given by Professor Callendar to reconcile Knoblauch and Jakob's results with the fact that Joule's law is accurately obeyed.

It would be very unfair to attempt to saddle Regnault's figures with even half this amount of error without a repetition of his experiments.

In conclusion, I do not see why the method described in this paper should not be applied to all vapours and gases in order to determine the deviation constant from Joule's law. The essential difference between it and the throttling methods is that it takes advantage of the fact that a gas or vapour does not change its rate of flow when passing through an orifice if the high pressure is kept constant, and more than double what the low pressure is, even though we vary the low pressure at will. This allows us to change the pressure of a vapour or gas without the application of mechanical work, and the change is performed without gain or loss of heat, all radiation error being eliminated.

TABLE XIV.

(To replace Table XII. in original paper.)

AVERAGE VALUES OF THE SPECIFIC HEAT OF SUPERHEATED STEAM (K_s°) FROM SATURATION TO S° F. SUPERHEAT, AT ATMOSPHERIC PRESSURES. FOR THROTTLING CALORIMETER.

Superheat in deg. F. S° F.	Average Specific Heat from Saturation to S° F. Superheat K_s°	Superheat in deg. F. S° F.	Average Specific Heat from Saturation to S° F. Superheat K_s°
1	1·43	22	0·478
2	1·27	24	0·463
3	1·14	26	0·451
4	1·04	28	0·441
5	0·95	30	0·432
6	0·88	35	0·414
7	0·82	40	0·400
8	0·77	45	0·389
9	0·72	50	0·381
10	0·68	60	0·368
11	0·65	70	0·359
12	0·62	80	0·352
13	0·597	90	0·347
14	0·576	100	0·343
15	0·558	200	0·324
16	0·543	300	0·318
18	0·516	500	0·313
20	0·495		

* Proc. Roy. Soc. 1900, No. 438, p. 268.
† Proc. Roy. Soc., 1905, No. A509, p. 186.

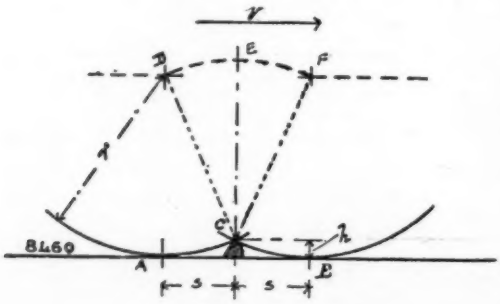
RAILWAY NOTES

Rail Corrugation and Curved Track.

In the course of an interesting paper on the above subject read before a students' meeting of the Institution of Civil Engineers, Mr. A. T. Arnull examined, with great lucidity, the effect of a curved track on two equal wheels fixed to the same axle.

Since speed beyond a certain limit is such an essential feature to produce corrugation, it may be supposed that centrifugal tendency will make the pressure greater on the outside rail, so that slipping will be confined to the wheels on the inner rail. The friction will there be a mixture of rolling and sliding; on the outer rail there is rolling friction only, modified in a way which has to be explained. The rolling body produces a deformation of the surfaces in contact, and a certain sliding friction is set up between them as they recover their original forms. It is unnecessary to add anything to this, so long as the velocity of the rolling body does not exceed a certain limit, in the paper called the "critical speed." But the new conditions which arise when this limit is exceeded must be taken into consideration in any attempt to deal with the question of corrugations.

Suppose, in the diagram, a wheel of radius r passing along with velocity V meets with a hard obstacle of height h. It leaves the rail at some point A, and meets it again at some point B, and while passing from A to B the axle traverses the arc, $D\ E\ F$, whose centre is C, the summit of the obstacle.



Let S = half the distance between A and B, then

$$S = \sqrt{2rh - h^2}.$$

But h being very small, we may say

$$S = \sqrt{2rh} \qquad (1)$$

The time occupied by a body falling through a height h is

$$t = \sqrt{\frac{2h}{g}} \qquad (2)$$

The velocity of a wheel which passes over a space S in t seconds is

$$V = \frac{S}{t} = \frac{\sqrt{2rh}}{\sqrt{\frac{2h}{g}}} = \sqrt{rg} \qquad (3)$$

If the speed of the wheel exceeds this velocity, it cannot reach the level again until it has passed a greater distance than S—*i.e., for a certain space it must be free from contact with the rail.* The importance of this result arises from the fact that the critical velocity is independent of the height of the obstacle—that is to say, in rolling along a rough rail, at a speed greater than V, an unloaded wheel $2r$ in diameter is not in continuous contact with the rail: every element of roughness, which is not crushed out of existence by the weight, frees the wheel for a small space from contact with the rail, and creates what may be described as a "looseness of contact" between the two surfaces.* From (3) it can be seen

* The distance traversed by the wheel before it again comes in contact with the rail is greater than the above consideration would imply. The critical velocity, V, as there defined is the lowest at which a body can move in a circle of radius r under the conditions given. For

that V, the critical speed, depends only upon the radius of the wheel and the value of g. The acceleration is equal to 32 *only* when force is that due to the weight of the wheel, axle, and other load that may be upon them below the springs. When the acceleration is increased by the resilience of the loaded springs it takes a new value, which may be found thus: The motion of the springs—so far as they are concerned with the corrugations—is very small. We may, therefore, consider them as "embodied forces."*

Let f = acceleration due to springs. (3) now becomes

$$V = \sqrt{r\,(g+f)} \qquad (4)$$

To find f: Let W = mass above springs $= W\,g$ in poundals; P = mass under (and moved by) the springs.

Then $\quad Wg = Pf. \qquad f = \frac{W}{P}g.$

From (4)

$$V = \sqrt{r\,(g+f)} = \sqrt{r\left(g + \frac{W}{P}g\right)} = \sqrt{rg\left(\frac{P+W}{P}\right)} \qquad (5)$$

As an illustration: The total weight of a certain electric car is 10 tons, or 5,600 lb. at each wheel. Of this, the dead load of wheel, half axle, quarter motor, and its gearing, being the parts below the springs, amounts to 940 lb., leaving 4,660 lb. above the springs.

W = 4,660 lb. mass;
P = 940 lb. mass;
r = 1·3 (a 31 in. wheel) say.

Then $\quad V = \sqrt{1{\cdot}3 \times 32 \times \left(\frac{5{,}600}{940}\right)}$,

= 15·7 foot seconds
= 10·7 miles per hour.

The acceleration, f, however, as treated in the example, is not at all effective, because of the friction between the axle boxes and the horn plates. This must be considerable on a curved track. It virtually constitutes an additional load to be shifted by the resilience of the springs, and, therefore, makes the downward acceleration less than it otherwise would be. The critical speed at which loose contact commences is, therefore, lowered, and the conditions favourable to vibration arise at a lower speed than that obtained by the method indicated. It follows that for speeds below this limit, whatever their value may be, the wheels of the car may be supposed to roll—and perhaps slide—in continuous contact with the rail, and above it the contact will not be continuous. The effects of centrifugal force on a curve may modify the action as affecting the two rails, but the general result will be as stated.

The principle of looseness of contact above a certain critical speed being admitted, it is evident that as a car rounds a curve we have all the elements necessary for a torsional vibration of the wheels and axles. The drag on the inner wheel caused by the slip twists the axle against the resistance caused by the wheel which does not slip: the loose contact gives frequent opportunities for the wheel to free itself, and the wheel flies backwards, to be caught up again upon resuming contact with the rail. By "backwards" is here meant the direction opposite to the rolling motion; it, therefore, gives a forward push to the metal displaced on the rail surface.

The action of the wheel may be very closely imitated by pressing the end of the middle finger in a nearly vertical position on the table and pushing it stiffly forward. In general it will not slide, but progress in a series of little jumps. The outer wheel of a tramcar on a curve moves in the same way. There is a rolling motion in addition, but it does not interfere with the vibration due to the rub and twisting of the axle. It has the effect of spreading out the corrugations, and bringing fresh parts of the wheel into contact.

In the Minutes of the Institution of Civil Engineers, vol. clxii., p. 385, a convenient formula is given for determining the periods of free vibrations of loaded shafts. It is there shown that in a shaft of mild steel, if d = diameter of shaft in inches, l = length of shaft in inches, I = moment of inertia of the "load" in $\frac{W}{g}r^2$ pounds-foot units; then the frequency, f, of the vibrations, or the number per second $= 50\,d^2\sqrt{\frac{1}{L\,I}}$.

Applying this to the case of the car wheel and axle above dealt with, we have I=12·8 pounds foot units; l=36 in. on a 3 ft. 6 in.

---

centrifugal tendency $F = \frac{m\,V^2}{r} = \frac{W\,V^2}{gr}$; so $V^2 = \frac{Frg}{W}$

which $= rg$ when $F = W$. If, therefore, this value of V be exceeded, the centrifugal tendency in passing the highest point exceeds the weight, so the wheel could not remain in contact with the obstacle. The "jolt" will carry it to a greater height than h, and it will describe a path everywhere above the arc, $D\,E\,F$; so the time during which it is not in contact with the rail will be greater than that due to a free fall through the space h. It will suffice to mention this point: the actual time of freedom from contact is not a material part of the argument, and it is not necessary to suppose the "freedom" to be absolute.

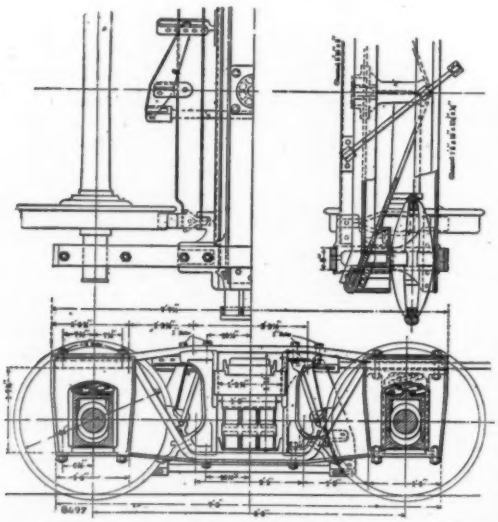
* This approximation is sufficient for the present purpose, but a thorough investigation of the effects of differently loaded springs would form an interesting subject for a future paper.

gauge tramway, or 50 in. on a 4 ft. 8½ in. gauge tramway, giving

Diameter of axle.	Vibrations per second On 3 ft. 6 in. gauge.	On 4 ft. 8½ in. gauge.
3·5 in. ...	28 ...	24
4·0 in. ...	37 ...	32
4·5 in. ...	47 ...	40

The periods of freedom given by the loose contact are, however, too short to admit of more than a fraction of the complete swing being completed: the swing is arrested as soon as the wheel comes to a bearing again upon the rail, the shock and simultaneous rub pushes the metal of the rail forward, and an element of the corrugation is formed. As soon as the contact is complete, the axle is again twisted up and the action repeated.

It is useless to attempt to stop the vibrations, since they arise from mechanical conditions which are practically beyond control, but the desired end could be attained if their effects on the rail did not accumulate. Probably a sufficient variation in pitch would be produced by a small increase or reduction in the diameter of one axle on every car, or it might be necessary to use axles of three or four different diameters. Further investigation is necessary before the precise value of the axle diameter on the corrugations can be determined, but it is believed that a fuller knowledge of the influence of this factor in the question will lead to a remedy being found for the present costly and troublesome nuisance.



NEW TYPE OF ARCH BAR TENDER TRUCK, CANADIAN PACIFIC RAILWAY.

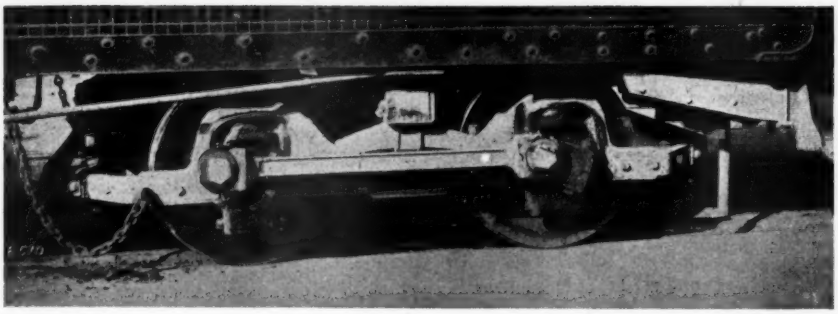
Tender Truck, Canadian Pacific Railway.

The Canadian Pacific Railway is equipping the Pacific type locomotives, which it is building, with a new type of arch bar tender truck. According to the *American Engineer and Railroad Journal*, the trucks formerly used were of the ordinary arch bar type, and considerable difficulty was experienced due to the breaking of the arch bars, especially the lower ones, during the severe winter weather. Column bolts were also broken and the threads sheared off at the ends due to hard track conditions. To overcome this, and at the same time make an easier riding truck, the design was changed to permit the use of coil springs over the journal boxes. The cast steel column castings, as shown in the illustration, are carefully designed to support or reinforce the arch bars at the bended portions where they usually fail. Short column and journal bolts are used in place of long ones to insure the parts being drawn together more securely and to facilitate repairs. A lug or projection is cast on the column castings from which the brakes are hung. Simplex bolsters are used.

Experiments with Electrical Treatment of Boiler Water.

For a length of considerably over 100 miles the water on one of the American lines is of an extremely bad quality, causing a high cost of maintenance on locomotives. By the lime and soda-ash treatment it has been found impossible to reduce the incrusting solids below 20 grains per gallon, and experiments have consequently been recently conducted with the electrical treatment of these waters. The engineer of the railway in question gives the following particulars of the method of treatment.* It consisted in submerging aluminium or iron plates in the water to be treated and passing an electric

* Bulletin No. 91. American Railway and Maintenance of Way Association.



SIDE VIEW OF TRUCK WITH CONNECTING ROD.

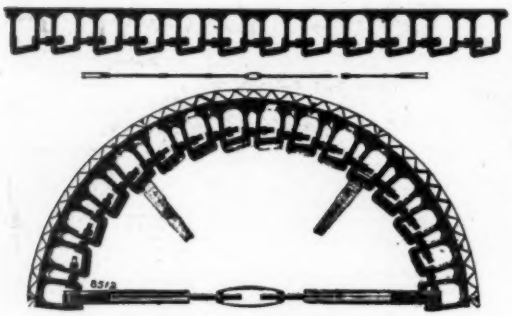
(From the *Street Railway Journal.*)

current through the plates, which are suitably connected up in series. The experimental treating plants consist of a series of wooden vats, each of which is divided into a number of compartments, each compartment containing a large number of aluminium or iron plates set on edge in grooves and spaced from ½ in. to 1 in. apart. In one of the plants the water flowed continuously by gravity through the vats. In the other the vats were filled and the water remained stationary until treated, when it was emptied and the vat refilled. For a number of reasons the intermittent treatment would probably be the more practicable in continued use. The aluminium plates experimented with were about 12 in. wide and 3 ft. long; the iron plates are about 3 ft. square. Both kinds of plates are dissolved in proportion to the amount of water treated, and we find the expense of the renewal of plates is a very large item in the cost of treatment. As a result of the experiments, our conclusions are that the electrical treatment is not practicable on account of the cost and the large amount of work involved in the daily operation, cleaning and maintenance of the experimental plant. At Alamogordo we reduced the incrusting solids from 40 grains to an average of 6 grains per gal., and at Pastura from 140 to 30 grains. It was possible to still further reduce the Pastura water by increasing the intensity of the electric current and the time of treatment, but we have ascertained that the electrical treatment is impracticable on account of the excessive cost, which has run as high as 4*s.* 2*d.* per 1,000 gals. for the worst waters if treated down to 10 grains and less per gallon.

Coupling Rods on Electric Cars.

The Pittsburg Railways Company have recently carried out a series of tests to determine the relative economy of a four-motor car, a two-motor car of the usual type, and a two-motor car in which side rods are used to connect the pairs of wheels under each truck. Some results which are quite striking in their character have been secured.

A standard double-truck car of the Pittsburg Railways Company, measuring 40 ft. over all, and equipped with four 93-A "Westinghouse" motors, was selected for the trials. One motor was removed from each of the trucks of this car and the axles of each truck were fitted with coupling rods, as shown in the illustration. These coupling rods were of forged steel 4 ft. 6 in. in length, and were attached to the axles by cranks secured to an extension through the axle boxes. Tested over 2,000 miles with a car of similar type equipped with four of the 93-A motors, but having no coupling rod, the result showed a saving of 29·9 per cent. in k.w. hours in favour of the car fitted with coupling rods. Two of the motors were then removed and the car tested with a two-motor car of the ordinary type, with the result that over 500 miles run a saving of 15·5 per cent. was shown. Further trials of these cars over 900 miles on a hilly route, involving a 5 per cent. grade for 2,000 yards, showed a saving of 18·3 per cent. k.w. hours in favour of the coupled vehicle. Even on this extreme service the motors showed temperature rise above 60° F.



ADJUSTABLE STEEL CENTRE FOR ARCHES.

A New Adjustable Steel Centre for Arches.

A new form of adjustable and collapsible steel centre construction for arch work, described in the *Railway and Engineering Review*, consists of a number of sections, made either of malleable iron or of steel, bolted together and aligned to the desired curve by means of adjustment nuts between the sections. For ordinary work these sections are 5 in. long, 4½ in. wide, and 2 in. thick, weighing about 8 lbs. per lineal foot of rib. They are hinged together and locked by bolts passing through the upper corners, as shown in the illustration. For tunnel and other heavy arch work the sections are similar, but larger.

The use of the device is very flexible, as it can be built up from a 2 ft. radius to a radius of 40 ft. or longer, simply by adding on more sections. The turnbuckle tie rods have a U-shaped strap at each end, 12 in. long, with a hole near its end through which a pin is placed for attaching to any part of the rib desired. A number of rods, from 2 to 5 ft. each in length, are connected by an ordinary sleeve. This turnbuckle can be adjusted to any possible distance from 4 ft. upwards.

The arch ribs are braced with struts permitting of a spacing of 20, 24, 30 and 40 in. The lagging is made of corrugated iron, of requisite strength, and is attached to the ribs by means of small bolts, or it can be nailed or screwed to a strip of board 2 in. wide and 1 in. thick. This strip of board is attached to the rib by means of small bolts. It is altogether optional about using the wooden strip, as it is not necessary except when wooden lagging is used. When placed, the corrugated lagging is covered with thin, flexible plates of sheet iron, which screw into small lugs fixed to the under side of the plates.

Both the corrugated lagging and thin plates are adjustable in relation to each other, also to different spans and curvatures of the arch as well as different spacing of the ribs. It is cut in lengths and widths of light weight and easily handled. If desired, ordinary wooden lagging can be used, by being nailed to the wooden strips, although it will be found that the iron is much more economical, as it costs less to place and can be used indefinitely.

After the sections are once assembled they can, for convenience, be taken apart in lengths of 5 or 6 ft., for transportation, and need never be detached into shorter lengths.

In forming the ribs the desired arc is described on a platform and a strip of board 1 in. thick and 1½ wide is laid on edge and nailed to cleats along the line described. As many sections as are necessary to make the rib are then interlocked and the nuts on the bolts loosened a little to enable the section to take the desired curve. The connected sections are then pushed against the wooden strip, the nuts tightened, and the rib is complete. The same strip is used to form all of the ribs, so that they will be alike. In striking or lowering the centre, one or two bolts near the middle are loosened, a few turns given to the turnbuckle, and the centre is gradually drawn from the concrete.

A few sections with a flat side are made for the ends, so that the rib may rest firmly on the abutment. A complete circle or an oval-shaped centre may be formed if desired.

The Interaction between Wheel and Rail.

An important investigation has recently been conducted by Mr. Geo. L. Fowler for the Schoen Steel Wheel Co. concerning the mutual compression between the wheel and rail when under a load, its bearing on the durability of both and also on the adhesion of the wheels when used as drivers. In conducting the investigation, the coach or locomotive to be examined was run on to a specially prepared level length of line in which a 10 in. length of one of the rails was removable. This was smeared with red lead, and the wheel to be examined was allowed to rest upon it, and an impression so obtained. Similar tests, with in-

creasing loads, were also made in the laboratory. The area of contact between wheel and rail was thus obtained, and this considered in relation to the pressure exerted, the yield of the metal in both wheel and rail, the diameter of the wheel, and the behaviour of steel and cast-iron wheels offers some extremely interesting results. These are plotted on the accompanying diagram and average lines drawn which show the accumulated pressure per sq. in. of area under the actual loads imposed, the lines being an average of the results obtained. It will be seen, on comparing the lines of the 36 in. steel wheel and of the 33 in. cast-iron wheel, that there is comparatively little difference up to a load of 22,500 lbs., after which the load per sq. in. increases more rapidly with the cast-iron wheel than with the steel wheel. At a load of 37,500 lbs. there is a marked breaking down of the metal in the cast-iron wheel, showing that the crushing strength has been exceeded. The chief conclusions to be drawn from the investigation are (1) that the average pressure imposed on the metal of the wheel and rail is witihn safe limits at low loads, but when a load of 20,000 lbs. is reached the elastic limit of the metal is passed, and a permanent set appears in the rail. (2) The accumulated pressure at the centre of the area of contact is excessive at comparatively small loads, and is only prevented from doing injury by the support of the surrounding metal. (3) The effect of difference of diameter in wheels carrying the same load is insignificant and is only appreciable when the difference is great. Hence, it is immaterial, so far as stresses on the wheel or rail are concerned, whether small or large wheels, within the limit of practice, are used. (4) A hard unyielding cast-iron wheel inflicts more damage on the rail than a steel wheel, and the wear of the rail will be greater with the cast-iron wheels than with the steel wheels.

For full information concerning these interesting tests the *Railway Gazette* of January 3rd should be consulted, in which appears a series of instructive reproductions of the contact area diagrams obtained by the method explained above.

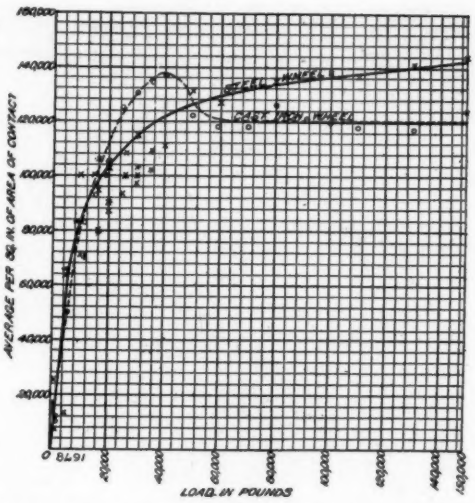
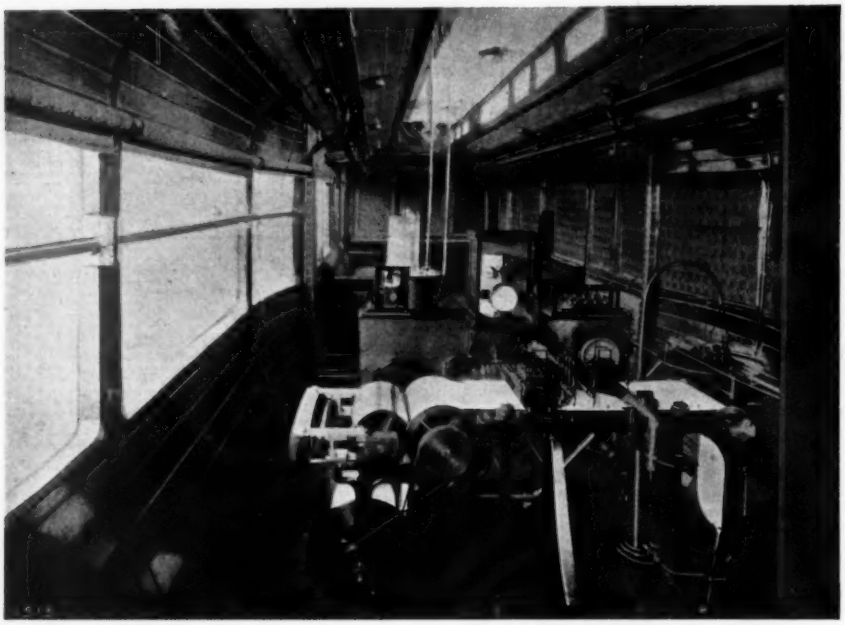


DIAGRAM SHOWING THE RELATION BETWEEN WEIGHTS ON WHEELS AND THAT ON THE AREA OF CONTACT BETWEEN THE WHEEL AND THE RAIL.

Dynamometer Car, North-Eastern Railway.

In our last issue a description was given of the new and elaborate dynamometer car of the Pennsylvania Railroad. The latest development in dynamometer car practice in this country is represented by the vehicle designed by Wilson Worsdell, chief mechanical engineer of the North-Eastern Railway, an interior view of which is given on the following page.

The body is built on a steel underframe, shaped to take a special spring consisting of thirty selected steel plates, each separated by rollers, to minimise friction. The end of the spring adjacent to the drawbar is provided with rollers at each end of the span abutting against fixed faces, and from these the pull is transmitted to the train. Each plate composing the spring was tested separately by being placed over supports and loaded until the specified deflection was reached, after which it was allowed to return to a horizontal position by unloading, or, failing in this, was rejected. A uniform rate of deflection was also required. After being put together the spring was carefully calibrated. A bracket which is fixed to the buckle projects inside the car, and as the spring is deflected the bracket moves a stylographic pen over a roll of paper, thus producing a curve of drawbar pull. The paper is caused to travel over a table by drums driven by a measuring-wheel, which rolls on the rail, and which can be raised or lowered from within the car at will. This measuring-wheel is fitted with a very hard steel tyre to minimise wear, and accurately ground so that it makes a predetermined number of revolutions per mile. The paper can be made to run at varying speeds by changing the driving gear between the measuring-wheel and the drums. The speed of the train at any instant



THE INTERIOR OF THE DYNAMOMETER CAR, N.E. RAILWAY.

is shown in front of the operator by a pointer on a dial. The permanent speed record is given by a pen in electrical communication with a clock, which thus makes a mark on the travelling roll of paper at two-second intervals. The speed can be read off from this by the aid of a special scale. There are eight of these electro-magnetic pens, which may be coupled up as required through a terminal board, and thus may be put in communication with any instrument. By the aid of connections at each end of the car external communication can also be made. The illustration shows the electro-magnetic pens and the bracket underneath the table extending from the spring buckle to the spindle on which the drawbar pen is fixed. On the front of the case on the far side of the instrument table are four dials which show the distance travelled, and above them, looking from left to right, can be seen the clock, boiler pressure recorder, and a meter for registering the work done. To the right of the instrument table is the apparatus for measuring the work done, and is on the same principle as a planimeter. The horizontal circular plate moves a proportional distance to that of the train, whilst a frame supporting a small wheel on edge moves across it from the centre, a distance proportional to the pull on the drawbar. Its revolutions are therefore a measure of the work done, and as it is in electrical communication with a meter, the work is recorded.

The indicator mounted on the near edge of the table is for recording the pressure in the steam chest. Owing to the fluctuating pressure in a locomotive steam chest it was thought that the inertia of the long column of water in the connecting pipe would make the results worthless. Two indicators were therefore bracketed together with the pencils close to each other, and in the same horizontal line, so that they both marked on one common drum. One indicator was coupled direct to the steam chest through a connection under 3 in. in length, whilst between the other indicator and steam chest, 60 ft. of bare copper pipe and an oil cylinder were interposed. It was found that the one in connection with the long pipe drew a line which was a mean of the pressure shown by the other.

An instrument seen behind the clock is for obtaining the velocity of the wind, which blows down a tube kept facing its direction, and causes the rise and fall of a pen on the paper drum. The direction of the wind is indicated by means of a dial in the roof. Two dials on which the drawbar pull and speed are shown are provided for the convenience of those persons who may be in the front end.

LEADING ARTICLES OF THE MONTH—CURRENT EVENTS—TECHNICAL INFORMATION FROM ALL SOURCES.

An International Road Congress.

An International Congress, to consider the preparation of the roads in view of their adaptation to modern traffic, is to be held in Paris at the end of 1908.

Since the development of mechanical locomotion, the macadamised roads appear to be unfit to resist the strain which is put upon them. Even if it had been proved by the numerous trials made almost everywhere during the last few years that tarring is really such an improvement as will constitute the solution of this problem so far as concerns roads over which an ordinary traffic runs, it is nevertheless undeniable that, for roads over which a heavy traffic travels, complicated with automobile circulation, macadam seems to have had its day, and tarring can only be, for such roads, a temporary and insufficient remedy. Their transformation into paved roads of either stone, wood or asphalte, becomes more necessary every day, and is imperative not only from the point of view of mud and dust, but also from the point of view of cost of construction and of maintenance.

The choice of a material for paving is necessarily subordinate to a host of local considerations. But it is curious, nevertheless, to notice that at Berlin all the road experts are in favour of asphalte, whilst in Paris the vote is unanimous in favour of a wood pavement.

Much light would be thrown upon this question by a comparison of the different methods of paving, and also by the results obtained from the various trials of tarring. Moreover the proposal to call an International Congress has met with a most favourable reception at the hands of the Minister of Public Works in France, who has decided that this congress shall be held at Paris at the end of 1908.

A committee of organisation will shortly be constituted by the "Commission of inquiry into remedies against the dust and for the preservation of roads," a commission appointed by the Minister of Public Works in 1905 at the request of the "Ligue contre le Poussière."

Although the acknowledged aim of this congress is limited exclusively to the construction and maintenance of the roads, and the comparative study of different paving materials, pavements of wood and of stone, asphalte, macadam and tarring, of the cost of laying same, their maintenance, and their respective resistance to modern methods of locomotion, the commission has decided to include in this committee of organisation not only those who construct the roads, but also those who use them.

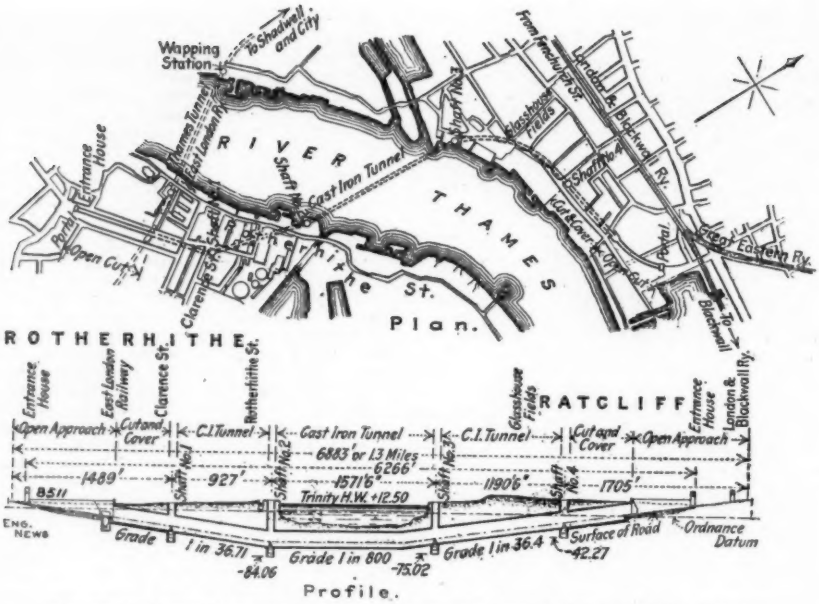
Great interest appears to be taken by the French Government in the organisation of this congress, the Minister of Public Works having personally taken the chair and presided over the first meeting of the committee.

It is to be hoped that responsible institutions will accept this invitation to discuss a question of such actual importance. Others who are interested may obtain full information from Dr. Guglielminetti, 76, Avenue Malakoff, Paris.

The Rotherhithe Tunnel.

Rapid progress is being made in the construction of the Rotherhithe Tunnel, which will provide accommodation for vehicles and foot-passengers between Stepney on the one side and Rotherhithe on the other. At present the shortest route between the points at which the approaches join the existing streets is by way of the Tower Bridge, a distance of over three miles. By the tunnel the distance will be 1·3 miles. An alternative route is by the Blackwall Tunnel, in which case the distance is about six miles. An important feature is that the new tunnel will afford a direct route from the Surrey Commercial Docks to the north and east parts of London. The resident engineer, Mr. E. H. Tabor, M.Inst.C.E., contributes a detailed article to the *Engineering News* * on the progress of the work, from which we gather the following general description:—Commencing on the south side of the river in Lower Road, Rotherhithe, the approach of the tunnel descends in open cutting for a distance of 934 ft., crossing the East London Railway by a bridge. It then enters the cut-and-cover portion of the tunnel, which has a length of

* Vol. 58, No. 25.

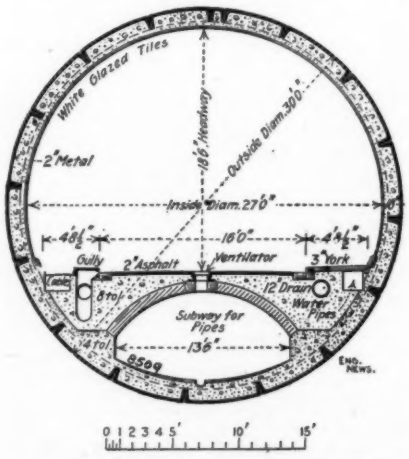


PLAN AND LONGITUDINAL SECTION OF THE NEW ROTHERHITHE TUNNEL UNDER THE RIVER THAMES.

540 ft. and terminates in No. 1 shaft. At this shaft the roadway is 44 ft. below ground level. The cast-iron lined, shield-driven tunnel begins here and descends on the same grade to No. 2 shaft, which is situated close to the river. A distance of 890 ft. separates Nos. 1 and 2 shafts, and the tunnel passes under a metal refinery and the South Metropolitan Gas Works. From No. 2 to No. 3 shaft is the subaqueous section of the tunnel, 1,535 ft. long and nearly level, the up-grade beginning about 270 ft. from No. 3 shaft. At the southern end of this section (at No. 2 shaft), the tunnel attains its greatest depth; the roadway is here 75 ft. below ground level, and the invert of the tunnel lining 97 ft. below high water in the river.

From No. 3 shaft the tunnel rises on the same grade to No. 4 shaft, a distance of 1,155 ft., and passes round a curve of 800 ft. radius. The tunnel for the greater part of this distance is under buildings. The total length of the cast-iron lining is 3,580 ft. North of No. 4 shaft is a length of 600 ft. of cut-and-cover. This is followed by the open approach, which is 1,186 ft. long, and terminates in Commercial Road East. The total length of tunnel and approaches is 6,883 ft., or 1·3 miles.

The tunnel proper, of which a cross-section is shown, has an outside diameter of 30 ft., and is 27 ft. diameter inside the finished surface of the lining. The clear headway in the centre of the roadway is 18 ft. 6 in. The cast-iron lining is 2 in. thick in the body in the subaqueous section, and 1¾ in. elsewhere. The heavy lining weighs 41,500 lbs. per ring, and the lighter section 36,750 lbs. The flanges are



TRANSVERSE SECTION OF THE NEW ROTHERHITHE TUNNEL.

14 in. deep. Each ring is 2 ft. 6 in. wide, and consists of 16 segments and a key. There are 164 bolts of 1¼ in. diameter in each ring. The cast-iron segments will be filled up with concrete after erection, the exposed surface being covered with white glazed tiles. The tiled face is 4 in. beyond the flanges of the segments. The lighting of the tunnel will be by three rows of electric incandescent lamps.

The work is being carried out by means of a pilot tunnel 12 ft. 6 in. diameter down in front of the tunnel proper. An excavating machine is employed for this work, consisting of a wheel fitted with knives and buckets revolving across the face of the heading. The excavated material is tipped from the buckets to a conveyor, by which it is delivered into small trucks for removal.

Keyham Dockyard Extension.*

The Keyham Dockyard Extension is situated north of the Keyham Yard, and occupies an area of 118 acres, of which 77 acres were mud foreshore. The works consist of three graving-docks, two of them opening into a tidal basin of 10 acres at the south end, and all of them opening into a closed basin of 35½ acres at the north end. Also of a lock giving access to the closed basin. A retaining-wall has been built along the east boundary of the new works, which adjoin the higher ground of the Naval Barracks. The new works necessitated the diversion of sewers and the construction of new outfalls. The whole area of the works was enclosed on the water side by a coffer-dam 5,576 ft. in length, which entirely excluded the tidal water. Portions of the works situated landward of high-water line were commenced while the coffer-dam was being constructed. The tidal basin is 10 acres in extent; the walls are everywhere founded on rock, the depth varying from 57 ft. to 80 ft. below the coping, and the bottom of the basin being 55 ft. below coping. The walls are constructed of concrete, the upper part faced with granite. The face of the wall is formed to a batter of 1 in 8 in the upper part, in the lower part to a batter of 1 in 4, the two parts being joined by a curve of 135 ft. radius. On the west side is the entrance 120 ft. wide. Timber fendering is fixed to the upper part of the walls. The closed basin is 35½ acres in extent, including the pier, and the formation of the walls is practically the same as for the tidal basin. The height of the walls from foundation to coping varied from 57 ft. 6 in. to 108 ft.; the bottom of the basin is 55 ft. 6 in. below coping, and 32 ft. 6 in. below low water of spring-tides. From the centre of the north wall a pier extends into the basin; this pier is 500 ft. long and 75 ft. wide. On the west side of the basin an entrance is constructed 95 ft. wide, and with a depth on the sill of 32 ft. at low water of spring-tides. The entrance is closed by a sliding caisson, and also by a floating caisson.

When the mud had been removed from the site of the docks, and the rock cut out to the form and depth required, concrete was deposited, the average depth under the centre part of the floor being 14 ft., and under the side parts 12 ft. 6 in. The concrete was deposited in sections, and to the full depth, to avoid horizontal joints. The floor-stones of granite were bonded into the concrete and bedded in cement-mortar. After the concrete of the floor was completed, the side walls were commenced. Up to the level of the first broad altar, the beds of the granite face-stones radiate, the concrete at the back having been first deposited and shaped to receive the face-stones. In the upper part of the walls the face-stones were set on a level bed, and afterwards backed with concrete. The walls of the docks and lock above the top broad altar are faced with concrete blocks having a granolithic face. Each dock and lock is provided with steps and slides. Dock No. 4 is 650 ft. long, Dock No. 5 is 745 ft., Dock No. 6 is 741 ft., and the lock is 730 ft. long. All the entrances are 95 ft. wide, and fitted with sliding caissons. In Docks 5 and 6 a floating caisson is fitted into a groove dividing each dock into two separate docks, if required. The width of all the docks on the floor is 70 ft., and at the coping 121 ft. The lock is constructed so that it can be used at any time as a graving-dock. The depth of water at low water of springs on the sills of Docks Nos. 4 and 5 is 20 ft. 6 in., of Dock No. 6 and the lock 32 ft. The floor of each of the docks is 4 ft. 6 in. below the floor of the entrance, the two floors being connected by five steps of granite set to a curve on plan with radial joints.

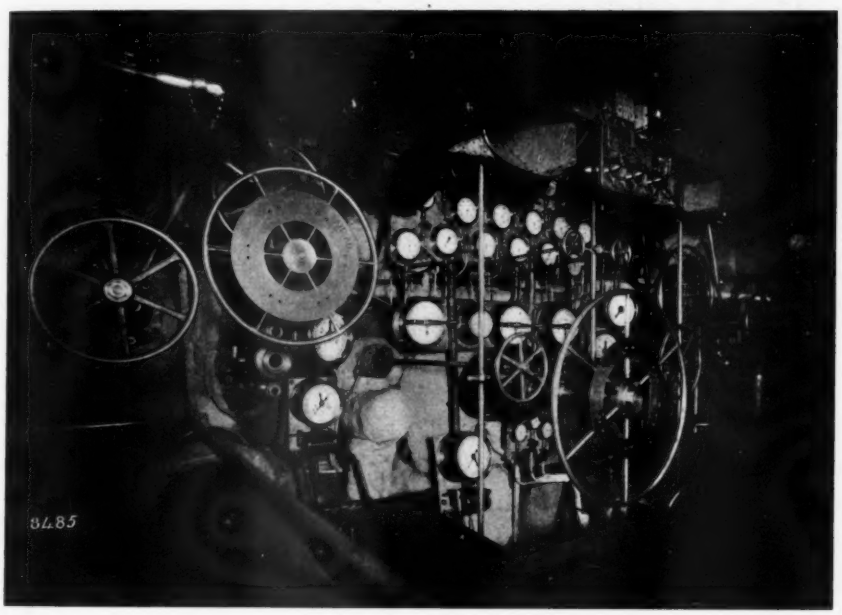
The outer wall forms the west and north boundary of the new works, and extends from the south end of the lock to a point near to the north of the Naval Barracks. The total length of the wall is 4,730 ft.; it is founded throughout on rock. For half the length the depth of mud varied between 30 and 60 ft., and for the remaining half it varied between 60 and 100 ft. In order to reach the rock through such a depth of mud a special form of concrete column was used. These columns were built in rings 2 ft. 6 in. thick, the rings being in sections, and jointed with cement-mortar. Three wells were formed in each column, through which excavating grabs worked, and brought up mud from the bottom of the column. The base of each column was provided with a cutting ring of concrete 5 ft. in depth, and formed in one piece, strengthened with iron bands embedded in the concrete. The ring was made *in situ*, and when it was ready to be sunk, built-up rings were added, and the mud was lifted from the wells by grabs, weights being placed on the top of the column to force it through the mud. The columns were sunk until the rock was reached, which was then levelled by hand, and the wells

* *Proceedings Institution Civil Engineers.* Sir Whately Eliot, M.Inst.C.E., and G. H. Scott, M.Inst.C.E.

were filled with concrete. When the depth of mud did not exceed 60 ft., a single row of columns was sunk, and a timbered trench was excavated at the back, in which the back part of the foundation was constructed of concrete, which was packed around and between the columns, spaced 10 ft. apart. When the depth of mud exceeded 60 ft. it was necessary to sink a double row of columns, 3 ft. apart transversely. The spaces between the columns were then cleared of mud and filled with concrete. The sinking of the columns was carried out very successfully, and a solid foundation was obtained on which to build the upper wall, which is faced with concrete up to 26 ft. 6 in. below the coping, and above that level with granite, to which is attached a fendering of timber. For filling the docks with water, two culverts, 8 ft. high and 6 ft. wide, are provided at each end, and fitted with penstocks. For emptying the docks two main culverts, 7 ft. in diameter, are provided, one at each end, and connected by branch culverts to the interior of the docks. The water is conducted by these culverts to the main pumping-engines. Subways are constructed at the back of the basin-walls and outer wall, in which are placed two cast-iron pipes, 9 in. in diameter, for the supply of fresh and salt water, and also a cast-iron pipe, 15 in. in diameter, for conveying compressed air from the compressors in the engine-house, for working the caissons, penstocks, and other machinery. The sliding caissons at the entrances to the docks, lock, and closed basin are box-shaped and constructed of mild steel; their buoyancy is adjusted by iron ballast and water. They are hauled into and out of the chambers by chains worked by compressed-air engines. The floating caissons are constructed of mild steel, and are raised or lowered by adjusting the water ballast in the tanks. The main pumps for emptying the docks are in duplicate, and of the vertical-spindle centrifugal type revolving horizontally; the spindle is driven direct by a horizontal compound steam-engine. The drainage pumps are in duplicate, each set consisting of three single-acting lift-pumps worked by a set of vertical compound engines. The pumps all working together are capable of lifting 6,600,000 gals. per hour, Two duplex pumping engines are also provided for lifting sea-water from the tidal basin to a large tank fixed on the roof of the engine-house, from which a supply is carried to various parts of the dockyard. By dredging, a depth of 32 ft. of water at low water of spring-tides has been obtained along the outer wall, except for the portion facing Weston Mill Lake, where the depth varies from 32 ft. at the west end to 15 ft. at the east end, where the new landing-stage for the Naval Barracks has been erected. The works were commenced in January, 1896, and completed at the end of 1906.

The temporary works and appliances which form the subject of the second paper were dealt with mainly under the following heads:—*Cofferdams.*—The works are situated at Devonport, on the estuary of the River Tamar called the Hamoaze, and two-thirds of the site required for the extension of the dockyard had to be reclaimed from the estuary. This was effected by a timber cofferdam nearly 8,000 ft. in length. Half of this length consisted of a double row of whole-timber sheet-piling driven about 40 ft. into the mud, and finishing at a level of 7 ft. 6 in. above h.w.o.s.t., the remainder being composed of a single row of whole-timber sheet-piling. At the most southerly end, the dam

H.M.S. "TARTAR" AT FULL SPEED.



VIEW IN THE ENGINE ROOM OF H.M.S. "TARTAR."

consisted of a temporary concrete wall about 300 ft. long and 30 ft. high. *Stagings, &c., for excavation.*—As there was a great depth of soft mud over the reclaimed area it was necessary to construct timber stagings upon which to work with steam-cranes and locomotives and wagons for the trench and other excavation, and afterwards for depositing the concrete for the basin and dock-walls. The total length of these stagings was about 6,000 ft. They consisted generally of three, and in some cases four, whole-timber piles driven to the rock when possible. *Unloading jetties.*—Two unloading-jetties for receiving materials required for the work were constructed, each 300 ft. long, being placed 39 ft. apart so as to provide a berth between them for the large craft bringing shingle and sand for concrete. *Concreting plant.*—Taylor mixers, of 1 cubic yard capacity, were used, nine of them, with the necessary stagings, being provided at various parts of the work.

Official Trials of the Fastest Warship.

H.M.S. *Tartar*, the new 33-knot British destroyer, which has already, in its preliminary trials, broken the recent world's record for speed by attaining 35·952 knots per hour on an Admiralty course, recently carried out its final speed trials in the presence of various Admiralty officials. The vessel maintained the unprecedented speed of 35·363 knots throughout a continuous run of six hours duration, thus covering a total distance of nearly 233 miles during this period. On six runs over the measured Admiralty knot during the six hours run the mean speed proved to be 35·672 knots, and the best speed attained on any one run was 37·037 knots, thus creating still another record.

Built throughout by Messrs. John Thornycroft & Co., Ltd., at their works opposite Southampton Docks, the *Tartar* is one of the first five high speed ocean-going destroyers now being completed for the Admiralty. So far her speed is very considerably in excess of that of any of the sister vessels by other builders, the fastest of which has attained only 34¼ knots.

The turbines of the *Tartar* are of "Parsons" type, and these, as well as the "Thornycroft" boilers using oil fuel, were constructed by Messrs. Thornycroft. The whole of the machinery worked excellently throughout the very severe trials, and the boilers provided an ample head of steam at all times. The oil fuel consumed was very considerably within the guaranteed limit.

The following comparative figures relating to the *Tartar* and other vessels of the 33-knot class are of interest :—

	Speed on Measured Course.	Speed throughout Six Hours Run.	Speed on best Run over Measured Course.
Cossack	33·15	33·1	33·65
Ghurka	34·00	33·91	—
Mohawk	34·51	34·245	35·294
Tartar .	35·678	35·363	37·037

With this new record to their credit it is interesting to recall that Messrs. Thornycroft built the first torpedo boat for the British Navy, and have always been in the forefront in the matter of speed of boats of this class. They created, amongst others, new world's records with the Spanish destroyer *Ariete* in 1886, with the *Daring* in 1894, the *Desperate* in 1896—this was the first boat to do over thirty knots—and with the *Albatross* in 1899; the last named vessel, with reciprocating engines, attaining over thirty-two knots.

Live Steam Feed Heating.

The following communication has been received from Mr. George Wilkinson, M.I.E.E., M.I.Mech.E., of Harrogate :—"My attention has been called to some observations in your December issue on 'Live Steam Feed Heating,' by Mr. Wm. Patterson, in which he states that there 'has recently been quite a resurrection of appliances for live steam heating,' but he 'is doubtful as to the economy resulting from such apparatus in every day working.' Mr. Patterson then goes on to state that these appliances are not new, and states that a reference to the Patent Office records will prove this. Finally he winds up by extolling the virtues of exhaust feed water heating and purifying plant.

"That the latter class of plant is, under certain conditions, both useful and economical I can testify after long experience, and that Mr. Patterson, being a manufacturer of this class of plant, advocates its use so ably, I can also understand. When, however, this gentleman advocates his own system at the expense of damning live steam heating, which, when properly applied, is capable of furnishing as great or greater economies than the former plant, I, as an interested party, am compelled to join issue with him. Further, live steam heating of the feed can and does furnish an economy which is superimposed upon any economies capable of attainment either by Mr. Patterson's apparatus or by improved combustion, or by both.

"On what grounds Mr. Patterson poses as an authority on live steam feed heating he does not inform us, but the very fact of his stating that 'internal live steam heaters are simply a resurrection of appliances adopted and abandoned years ago' proves that his knowledge is quite out of date.

"None of the obsolete forms of live steam heaters, and very few of the modern types of live steam heaters, furnish to the boilers water which is hot enough to give good economy. This economy goes up with great rapidity with the last few degrees increment of heat, bringing the feed water bang up to the temperature of the steam, hence the importance of employing an internal heater which will give full steam temperature to the feed water, and at the same time furnish drier steam from the boiler.

"There is no subject in connection with boiler house plant upon which there are wider or more emphatic differences of opinion between engineers than as to the economy or otherwise of using live steam heated feed water for boiler feeding purposes, the reason being that the subject is very imperfectly understood, and there are numbers of manufacturers selling live steam heaters who are evidently not conversant with the conditions necessary to produce economical results. In numbers of cases live steam heaters are at work ostensibly for the purpose of economising coal, but as a matter of fact they are entailing a heavier consumption of fuel than would be required were the boilers minus the live steam heaters.

"Live steam heating under certain circumstances substantially economises coal and greatly increases the output of steam for the boilers, but there are distinct limitations to the economy which can be obtained, and it is important that all steam users contemplating the adoption of such apparatus should seek competent advice on the matter, otherwise after having spent their money they may find that their consumption of coal instead of decreasing has increased. In view of the present high prices and prospective increasing cost of fuel, it is a matter of considerable importance that manufacturers and steam users who are wise enough to avail themselves of every economy should be carefully advised in this matter, or they may increase their coal bill and entirely miss the substantial economies and lessened fuel cost which live steam heaters are capable of producing."

Novel Reconstruction Work.

An interesting task is being carried out in Liverpool in the alteration of the City buildings. The building occupies a corner, and the feat consists of putting in a new front and side, taking out the whole of the basement so as to make a single apartment 120 ft. by 80 ft., and of putting in new foundations while the interior walls and floors of the building are standing. The front and side have been formed of steel framework. During the recent heavy gale the precautions taken to anchor the roof to the floors below with chain and steel wire ties and lashings proved sufficient to prevent movement, and the closest inspection has failed to discover any crack or other evidence of weakness in the building.—*Times Engineering Supplt.*

ELECTRICAL PROGRESS

By ANDREW STEWART, A.M.I.E.E.

Automatic Cab Signalling on Locomotives.

One of the most remarkable features of railway working is the fact that one branch —one might almost describe it as a detail— though an important one, has practically stood still since the introduction of railways, viz., the method of communicating between the signalman and the driver of a train.

The equipment of the signal box itself is almost a triumph of mechanical ingenuity, with its mechanical interlocking and electrical arrangements for indicating the position of the signals, but when it comes to the remaining link between the signalman and the driver, the latter has to depend on his visual organs, in clear weather, and his sense of hearing in dull or foggy weather, just as in the earliest days of railway working.

The electrified District Railway was, we believe, the first in this country to improve on the older method by projecting the handle of an air valve, fixed on the air brake pipe, below the truck, so that when the signal is at danger, this handle strikes a block which rises above the permanent way when the latter is operated by the signalling gear. A driver cannot therefore overrun a danger signal, as his brakes are automatically applied.

FIG. 1.—CAB INDICATOR FOR N.E.R. LOCOMOTIVE SIGNALLING APPARATUS.

The system described by Mr. J. Pegg to the Institution of Electrical Engineers a short time ago, while it does not do as much as this, gives both visual and audible warning in the cab of the locomotive of the position of the signals along the line.

The system is arranged so that metallic brushes, fixed under the engine, make contact with metal bars or ramps fixed between the rails, and alongside the track; the current so collected operating a small semaphore arm on a dial in the cab of the locomotive. In addition, a bell gives audible warning of the change in the position of the semaphore arm. There is, moreover, a failure indicator, quite independent of the other apparatus which, should the signalling circuit be interrupted, causes the semaphore arm to stand at danger, the bell to ring, and a small disc or grid to show red. Fig. 1 shows the indicator in the locomotive cab. The pointers at 1, 2 and 3, 4 are route indicators, and show "line clear" for a diverging junction to the left or "line clear" straight through.

The system has proved very satisfactory, so much so, that the North-Eastern Railway Co. are equipping fourteen miles of their main line track between Newcastle and Durham with it, and are fitting a number of their express engines with the requisite gear.

Another system is in use on a short length of the South-Eastern and Chatham Railway, between Beckenham and Norwood Junction.* Here the engine equipment has, in addition to the miniature semaphore arms, two small bulls eyes, red and green respectively for each signal, "home" and "distant," and a

* See also Vol. 17, pp. 419—420.

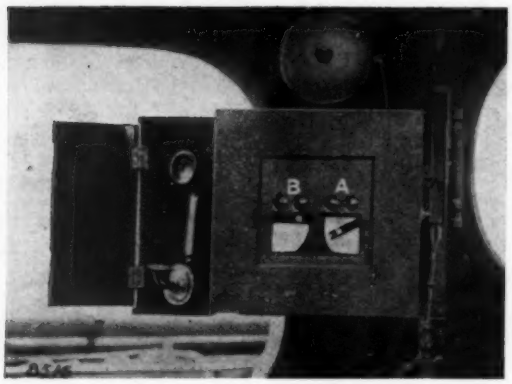


FIG. 2.—CAB SIGNALLING APPARATUS, S.E. & C. RAILWAY.

telephone by which communication may be effected between the driver and signalman via the same circuit as is employed for signalling.

The bell seen at the top of Fig. 2 is operated mechanically by the contact shoe striking the ramp.

Fewer contacts are used with this system, and, unlike the North-Eastern Railway arrangement, which involves ramps, not only between the rails, but also outside the track, the contacts on the track consist of ramps nearly in the centre of the track, standing about 10 in. above the ballast. They are 50 yards long, and consist of two rails separated from each other by about two inches. One of these rails supplies current through a contact under the engine, which operates the home signal, and another the distant signal.

As the bell is mechanically operated by contact shoes, it merely rings when the contact strikes or leaves the ramp. The position of the semaphore on the engine is determined by the position of the signal lever in the signal cabin, as the switches are closed by this lever, hence the driver cannot be deceived by "drooping" signals, as the position of the signal arm on the line in no way influences the position of the cab signal, though, of course, they will generally be in agreement.

The working of these examples of automatic cab signalling will no doubt be followed closely by railway engineers, as they appear to be the first to give satisfaction under normal working conditions.

We believe that another system has, within the last few weeks, been tried on the London and North-Western Railway. In this case, there is no electrical connection between the engine and the signal box. The operation of the signal lever raises a ramp formed of a T bar placed close to the running rail. When this T bar is raised it comes in contact with one or more plungers, which closes a local electrical circuit on the locomotive: this circuit operates the signal.

Three contacts are provided on the locomotive at three different heights from the rail. These engage three different T bars, each of which rise to a different height, and so different signals such as "distant," "home on," "home off," are given in the cab. These T bars are mounted on cranks, and operated by steel wire ropes just as are ordinary signals; the signal lever which operates the usual semaphore also operates the T bar.

It is said to be cheaper than the two previously described systems, and equally reliable. Moreover, the T bars or ramps are not in the centre of the track, so do not interfere with the water-lifting gear on express locomotives.

Some Recent Electric Locomotives.

Two locomotives of very different design, but embodying several features of interest, have recently been put into service in the United States. One of these, illustrated in Fig. 3, has been built by the American Locomotive Co. for the Portland Railway Co. The motors, which are by the (American) General Electric Co., have commutating poles, which enables very great overloads to be carried without commutator troubles. The locomotive has four motors, one on each axle; the driving wheels are 33 in. diameter, which is practically standard electric tramway size.

The tractive effort developed by the four motors is about 9,200 lbs. at 16½ miles per hour, and 20,000 to 25,000 lbs. at starting.

The other locomotive is by the Baldwin Locomotive Works, and intended for express service on the West Jersey and Seashore Railway. It marks a distinct step in the direction of standard steam locomotive practice, being the practical equivalent of a 4-4-0 steam locomotive. Hitherto electric locomotives, with the

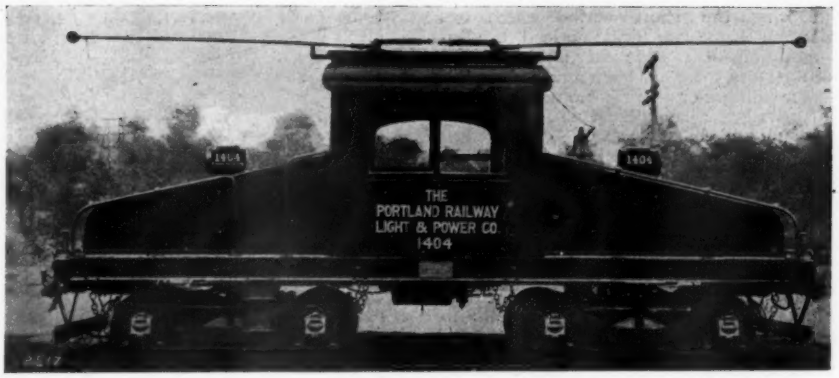


FIG. 3.—ELECTRIC LOCOMOTIVE FOR THE PORTLAND RAILWAY COMPANY.

exception of the 3-phase locomotives on the electrified section of the Italian State Railways, have been simply overgrown tramcars with tramcar wheels, tramcar trucks, strengthened where necessary, but always bearing the hall mark of their origin. There is practically no line of demarcation where it can be said that the tramcar ends and the locomotive begins, the locomotive being in fact an evolution from a tramcar, instead of being, as some railway engineers assert it should be, a distinct type.

It is, of course, hardly to be expected that engineers would be inclined to depart from designs which experience had demonstrated met most requirements, but it had to be recognised sooner or later that the steam locomotive engineer possessed much information of value to the electrical engineer, and that steam locomotive practice did not crystallise along certain well-defined lines without perfectly justifiable reasons; hence it is that at last we have an electric locomotive which embodies most of the features found desirable in steam locomotive practice.

From the drawing, for which we are indebted to the *Railway Gazette*, it will be seen that the locomotive has four driving wheels and a leading bogie. These driving wheels are much larger than usual in electric locomotive work, being 72 in. diameter. The only difference is that the four driving wheels are not coupled, this being to a certain extent unnecessary, as each of the axles are motor driven. The absence of the coupling rods enables outside axle boxes to be used on the drivers.

The motors drive the driving wheels through a quill which goes into the pockets, seen near the box of the driving wheels; these pockets have springs, which permit a vertical and lateral movement of the parts. This feature of the driving equipment is not new, having been first embodied in the design of the New York, New Haven, and Hartford Railway locomotives, which we illustrated and described in this column nearly two years ago.

The complete locomotive weighs 140 tons, 22½ tons being on each of the four drivers. Speeds of sixty miles per hour have been attained during the trials. It should be added that the locomotive is intended to operate on single-phase alternating current, and for that reason has single-phase series motors direct coupled to the driving wheels by means of the quills and pockets already alluded to.

The circuit on which this locomotive will operate is similar to that portion of the London, Brighton and South Coast line which is now in process of electrification.

Electrically Driven Textile Factories.

Nearly two years ago we gave some details of the first electrically driven cotton mill. At that time there was very little electrically driven textile machinery in this country, although the case was altogether different in the United States, where the high cost of fuel, and the relatively low cost of water power, stimulated the development of electric power distribution for such purposes.

During the short period which has elapsed, since we first noticed the inauguration of electric driving in British cotton mills, there has been a rapid increase in the number of electric motors in textile factories generally, and cotton spinning and weaving mills in particular. At the present time it is estimated that there are about 27,000 h.p. of electric motors in British textile factories, a quarter of which derive their power from central power distribution authorities.

This development has been stimulated by the low prices charged for electric power by the power companies, and a few local authorities, as low as ⅓rd of a penny in some cases where a considerable amount of power is taken steadily for ten hours per day.

There is apparently little advantage to be obtained from installing an electrical generating plant with electric transmission and motors, in place of the usual engine with rope tower and shafting. So far as the capital cost is concerned, indeed Mr. H. W. Wilson in a paper to the Manchester Section of the Institution of Electrical Engineers,* made out the capital cost of the mechanical equipment, *i.e.*, chimney and buildings, boilers, engines, reservoir, condensers, rope race and gearing of a spinning mill for 100,000 spindles, as £17,650, and for the electrical equipment, including turbo-generator motors, cables, gearing, etc., £16,832, a difference which is not sufficient to induce the man of conservative mind to display much enthusiasm for electric driving. The operating expenses were shown to be £4,413 per annum, against £4,119 for electric driving, still not enough to awake enthusiasm.

It is unlikely that any better working results will be obtained by purchasing energy from an outside source, but the mill owner is saved the expenditure of capital on power generating plant, which is foreign to his real business, viz., spinning and weaving. Power generation is left in the hands of specialists, and he purchases it, just as he buys his raw material.

The real advantage of electric driving is that he produces work of better quality, and, therefore, higher market value, or he may, by raising the speed of the spindles, get greater output. This latter is a real advantage, for the steadiness of the electric drive renders this possible. An increase of 5 per cent. in the output has been recorded in some mills, which raises the actual remuneration on the capital by 1½ per cent. It appears possible, at any rate it was asserted during the discussion on Mr. Wilson's paper, on the authority of Mr. W. B. Woodhouse, that the speed of the motor may be varied according to the number of layers on the cap. The diameter on to which the thread is wound naturally differs, and an increase in speed for small diameters would materially increase the output of a mill. Mr. Woodhouse also stated that the extra profit obtained from the greater output of an electrically driven spinning mill paid all the power costs of the mill; there were also fewer broken ends with electric driving.

Mr. C. D. Taite stated that one manufacturer, who had two weaving sheds, one of

* See p. 87.

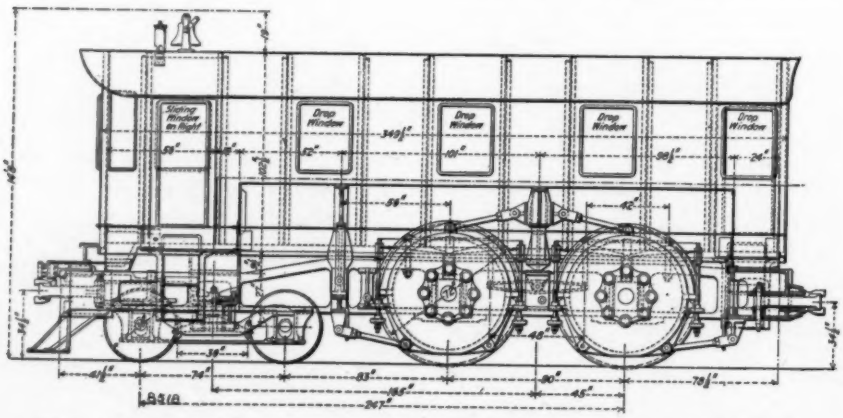


FIG. 4.—4-4-0 TYPE SINGLE-PHASE ELECTRIC LOCOMOTIVE FOR THE WEST JERSEY AND SEASHORE RAILWAY.

which was electrically driven, got better quality of cloth from the electrically driven looms. This was realised by customers, and there was a better demand for the cloth produced in the electrically driven shed.

All this goes to prove that, notwithstanding the exaggeration of enthusiasts, there is a sound commercial case for the electrically driven textile factory, when the conversion is properly engineered. It is obvious, however, that there is no particular economy to be gained, but the mill-owner must look to the aggregate of numerous small advantages for the realisation of his hopes of further profit.

The Development of Electric Power on the North-East Coast.

No electric power undertaking in this country has displayed such vitality as the Newcastle-on-Tyne Electric Supply Co. It has, octopus-like, spread itself over two of the largest and most densely populated industrial counties in England, absorbing or making friendly agreements with rivals in a manner which is unique in the history of electric power distribution in this country. The Carville power station is now almost three times as large as it was three years ago, and now contains 40,000 h.p. of generating plant, supplying, by means of underground cables, at pressures varying from 11,000 to 20,000 volts, The County of Durham Power Co.'s sub-stations, The Northern Counties Electric Supply Co., and The Cleveland and Durham Power Co. The latter Company operates chiefly in South Durham and the Cleveland District of Yorkshire, and, while it supplies the latter district from its own stations, purchases a bulk supply from the Newcastle Company, to meet its Northern demand.

The Aluminium Corporation, Limited, are almost ready to start their new works on the banks of the Tyne, and will take 5,400 h.p. from the Newcastle-on-Tyne Electric Supply Co., while the Castner-Kellner Alkali Co. are now taking some 20,000,000 h.p. hours per annum from the same source. This will, we understand, be increased shortly when new plant is delivered, indeed the remarkably cheap supply of electrical energy now available in the district will in all probability lead to the starting of many works producing chemical products by electrolytic methods, while the electric furnace will no doubt also play an important part in this industrial rejuvenation of the chemical and allied industries on the Tyneside, where many years ago the industry flourished, only however to die due to the growth of competitive industries in West Lancashire, and to combinations within the industry itself which, by consolidating the most successful concerns under one management, secured economies which smaller competitors could not introduce, thus freezing them out.

For many years past electrolytic methods have been adopted in West Lancashire with excellent results, and it is likely that the chemical works of the early future will no longer be an evil smelling agglomeration of huts and buildings, the fumes from which blight the country for miles around, but as pleasant and inoffensive as a modern engineering works or textile factory.

The Iron and Steel Institute: Carnegie Research Scholarship.

A research scholarship or scholarships, of such value as may appear expedient to the Council of the Iron and Steel Institute from time to time, founded by Mr. Andrew Carnegie (past president), will be awarded annually, irrespective of sex or nationality, on the recommendation of the Council of the Institute. Candidates, who must be under 35 years of age, must apply on a special form before the end of February to the secretary of the Institute. The object of this scheme of scholarships is to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches in the metallurgy of iron and steel and allied subjects, with the view of aiding its advance or its application to industry. There is no restriction as to the place of research which may be selected. The appointment to a scholarship shall be for one year, but the Council may at their discretion renew the scholarship for a further period instead of proceeding to a new election. The results of the research shall be communicated to the Iron and Steel Institute in the form of a paper to be submitted to the annual general meeting of members, and if the Council consider the paper to be of sufficient merit, the Andrew Carnegie gold medal shall be awarded to its author.

Iron, Steel and the Foundry.

Conducted by PERCY LONGMUIR.

FOUNDRY PRACTICE.

The Manufacture of Cast Iron Pipe.—A new plant designed for continuous production with a daily output of 750 tons has just been completed by the United States Cast Iron Pipe and Foundry Co. In designing the plant the pit method generally used has been adhered to, but tables have been installed on which the boxes revolve for successive moulding, drying, and casting operations. The moulds are rammed by machine which represents a distinct departure from prevalent practice. The four casting pits have been installed in two units each served by three jib cranes. The crane serving the rammers of each pit also removes the boxes after casting and places them horizontally on skids over a sand pit where the pipes are removed; the sand tempered and returned to the ramming machines. These machines are anchored in the centre of the moulding pits and have arms extending the radii of the tables in order to bring the ramming devices directly over the boxes. The movement of the pipe after casting is towards loading cars or stockyard, in its journey passing the cleaners, chippers, heating ovens and dipping tanks, scales and testing machines.

Turning to details of the construction of the revolving tables and pits we note that the latter are 74 ft. in diameter. The tables for carrying the boxes are supported on heavy concrete foundations surmounted by circular steel tracks. The tables are built from structural steel shapes and covered with steel plates. They are pivoted in the centre and also travel on an outside track, 20 per cent. of the load being carried on the centre and 80 per cent. on the track. Each table has a capacity of 94 double boxes for pipe up to six inches diameter or 58 double flasks for twelve inch pipe. The total weight of the table including boxes and castings is 700 tons. Revolution of the table is effected by a 10 h.p. alternating current motor. With these tables it is intended to make three casts daily. To accomplish this the moulds after ramming pass over coke fires in the pits and are dried before setting the cores. These coke fires extend two thirds of the circumference of the pit and the gases from them are drawn up through the moulds. After drying and setting the cores the table is revolved and the moulds poured. In the meantime other boxes which have been shaken out and returned to the table by one of the jib cranes are being rammed, dried, and cores set, the whole operation forming a cycle. By these means each mould is finished and poured within a little over three hours.

Specifications for Iron and Fuel.—In a paper read before the American Society of Mechanical Engineers, Dr. Moldenke gives a series of specifications for the use of iron and steel founders. Taking first machinery and malleable castings, it is shown that since the relative proportions of combined and free carbon may be largely controlled by the silicon it is generally sufficient to specify the allowable contents of sulphur, phosphorus and manganese. Therefore for ordinary machinery castings of grey iron the pig used as part of the charge should contain:—

	Per cent.
Sulphur not more than	0·05
Phosphorus ,, ,,	0·50
Manganese ,, ,,	0·80
Silicon from	1·75 to 2·75 as specified.

For malleable castings (white iron) the pig used should contain:—

	Per cent
Sulphur not more than	0·04
Phosphorus ,, ,,	0·225
Manganese ,, ,,	0·60
Silicon from	0·75 to 1·75 as specified.

A variation of 10 per cent. either way from these figures may be allowed. Where light castings are desired as for stoves and

art work the phosphorus is specified at 1·0 per cent. or over and the silicon often as high as 3·25 per cent. Similar specifications may be prepared to cover the rest of the 13 rather distinct grades of cast iron with their more than 40 variations. To enable foundrymen to buy intelligently the American Society for testing materials have prepared schedules designating the composition of the deceptive but well known grade numbers. Thus numbers 1, 2, 3 and 4 contain 2·75, 2·25, 1·75 and 1·25 per cent. silicon respectively, fracture appearances being disregarded. A variation of 10 per cent. is allowed, and a deficiency of over 10 and under 20 per cent. does not lead to rejection but entails a penalty of 4 per cent. in price.

Turning to fuel the necessity for specification is not so severe as in the case of iron, and in solid fuels is chiefly confined to sulphur and ash. Thus no coal containing more than 2 per cent. sulphur should be used in the foundry, and preferably the amount should be limited to 1 per cent. Similarly the amount of ash should be limited to 10 per cent. Coke demands closer attention to moisture, volatile matter, fixed carbon, sulphur, ash, and sometimes phosphorus. Usually, however, the sulphur, ash and fixed carbon are sufficient to give a fair idea of the value of the coke apart from its physical structure, specific gravity, &c. The advent of by product coke will necessitate closer attention to moisture. Beehive coke when shipped in open cars where it absorbs much moisture may cause the purchase of from 6 to 10 per cent. of water at coke prices. In good coke the amount of sulphur should not exceed 1·2 per cent., not over 11 per cent. ash and over 86 per cent. fixed carbon. Limestone to be used for fluxing should be as rich as possible in carbonate of lime, for each unit of silica transformed into slag exacts its equivalent of lime and coke. Oyster shells form a desirable flux and fluor spar tends to thin the slag.

Use of ferro-alloys will eventually be limited to the richer grades. It is wasteful to employ a rich alloy in the cupola, but in the ladle removed from the further application of heat the smaller bulk of the richer alloy causes a smaller reduction in the temperature of the molten iron. At present specifications are not required for these alloys which are made from the best material and should be low in sulphur and phosphorus.

In selecting scrap-iron each foundryman chooses material similar in composition to the proposed product. Beyond the exclusion of burnt or dirty metal, and of sizes so small as to cause waste in melting, specifications for scrap-iron should be limited to a statement of the class of material wanted, machinery, pipe, &c. Weak castings and castings with pin-holes or with pockets under the skin indicate the use of burnt metal. Three hundredths of 1 per cent. of oxygen in solution in the iron as an oxide or combination of oxides is in the case of white irons sufficient to ruin them completely. Oxygen in cast iron is far more deadly than sulphur, yet the action of the former is little understood and does not lend itself readily to chemical investigation.

Converter or Small Open Hearth.* —In his second article, Mr. Carr enters into the advantages of the converter and summarises them as follows:—(1) It can be cheaply installed; (2) It can be started at short notice and operated at irregular intervals; (3) It is well adapted for light sections; (4) It produces steel of such a high temperature as to permit of transference to hand ladles and lip pouring. This favours lessening the size of the gates and a better quality product in that the stream of metal is under good control; (5) The product is of good quality, bearing inspection in chemical and physical tests with that of open hearth or crucible steel of like composition. The disadvantages are summarised as follows:—(1) No objection can be cited against advantage. (1), (2) The possibility of irregular operation proves to be costly, for an organisation must be maintained during intervals of idleness. Continuous operation is the keynote in any steel casting method. Irregular intermittent work must yield uncertain profits, carry heavier charges for labour and management, &c., than steady regular production aside from any material cost or installation outlay. Continuous operation will be defeated with but one converter, for the latter must be taken off for repairs every twenty or more heats, and several days will be lost in relining, drying, and heating up again for service. Three 2-ton converters are recommended for continuous service, and the practice would then be one active, one in course of repair, and one warming up ready for use. The cost of an installation while lower than that of an average open hearth furnace will be about the same as a small open hearth plant, and therefore the element of cheapness will be open to question in regard to relative costs of the

* The *Iron Trade Review*.

two methods. (3) The adaptability of the converter to light sections is purely one of cost, and its value will be competitive with crucible steel or malleable cast iron. (4) The high initial temperature of converter steel brings into play a personal equation, and the judgment of suitable casting conditions rests with the foreman, whose practised eye is the sole guide. Should this judgment be at fault and the metal poured at too high a temperature there will be heavy losses through "hot cracks." The proper casting temperature being subject to eye measurement is a greater variable than open hearth temperatures and is therefore a drawback. The heavy losses previously mentioned do not allow for losses in defective castings, gates, skulls, risers, or fins, but refer only to differences between metal charged and that obtained in readiness to pour moulds. First there will be a cupola loss of from 5 to 6 per cent., and an additional loss in blowing of between 10 and 25 per cent. The total loss will therefore vary from 16 to 30 per cent. The economy of the converter process must depend upon such losses.

Foundry Cupola and Iron Mixtures.—In a paper read before the American Society of Mechanical Engineers, Mr. W. J. Keep discusses melting practice, stating at the outset that the proportions of a cupola exert almost no influence on the melting efficiency and that the results depend rather upon the skill or care of the melter. Taking first Mr. Keep's remarks on the cupola we note the following:—

The Lining.—Every test made by the writer has shown that for ordinary melting the cheapest stock brick may be used to good advantage. Square bricks are preferable, and key or arch bricks should only be used when necessary to turn the circle. A stock brick, whether square, split, key or arched will make as good a lining as the special shaped cupola blocks and is much cheaper. Under special conditions, as in continuous melting or when using steel scrap in the charge a more refractory (and expensive) brick may be required.

Overhanging Bosh.—The cupola described has an overhanging bosh formed by making the lining in the hearth 12 in. thick; this is increased to 16 in. until carried above the tuyeres, and from thence is gradually sloped back for 2 ft. until a thickness of 5 in. is reached, which is maintained up to the charging door. This construction carries the blast to the centre and favours rapid melting.

The Tuyeres.—When using coke as fuel and where the iron is drawn as quick as it is melted the distance from the bottom of the tuyeres to the sand bottom of the cupola should be about 12 in. For machinery castings the distance should be such that the iron can accumulate without entering the tuyeres. A good way to form a practically continuous tuyere is by means of segments 1 in. thick, and of a width equal to that of the lining at the tuyere circle. When the lining is built to within an inch of the blast openings in the shell a circle of the segments is laid. Cast iron blocks 3 in. by 4½ in. are placed even with the front of the circle and about 7 in. apart. Another circle of segments is laid on the blocks and the regular brick lining continued. This construction leaves an almost continuous tuyere and permits the blast to enter at all points with equal force.

The Blast.—With free entrance for air and with a positive blower the speed of melting can be increased by increasing the blast up to 18 ozs. pressure. No further increase in the rate of melting is obtained with 22 ozs., and with 26 ozs. pressure the melting will be slower, showing that more air is blown than can be used. About 14 ozs. is the best pressure for any kind of blower or cupola, and when speed is not required a lower pressure may give more economical results.

Charging and Running.—Full details as to kindling and charging up are given, but hardly require notice here. The time table is:—fire lighted at 12; charging begins at 12.30 p.m., and blast put on at 2 p.m., tap-hole stopped at 2.10 p.m., and tapping commences at 2.15 p.m. With 20 charges or 31 tons the blast should be off at 5 p.m. The fuel ratio is 9 : 1, and the rate 10 tons per hour. The cupola has a 72 in. shell.

Advantages of Hot Iron.—Iron should be melted hot, whether it is to be poured hot or dull. Hot iron is fluid, gases and slag can separate, and castings will be even in grain and free from blowholes.

Quality of Coke.—Coke should contain about 10 per cent. ash, and whilst sulphur should not exceed 0·75 per cent. it often reaches 1 per cent. or over. With 0·75 per cent. sulphur in the coke the increase of sulphur in the iron will reach 0·03 per cent., and as gates and waster castings are re-melted each day it is difficult to keep sulphur in the castings below 0·08 per cent., which is the limit.

Flux.—Limestone is the best flux and in a slight degree lessens sulphur; but its chief use is to form a fluid slag and thereby to keep a clean cupola. It is a question

whether the special fluxes on the market do as much good as is claimed, but they are worth a trial. Fluor spar is more efficient than limestone, but is more expensive. The writer gives, at some length, a series of mixtures, and also methods of calculating the same.

IRON AND STEEL.

Bessemer and Open Hearth.—A recent editorial in the *Iron Trade Review*, in discussing the replacement of Bessemer steel by that of open hearth manufacture, states that for years the steel industry has expected to see a fulfilment of the prediction that "The open hearth process will go to the funeral of the Bessemer." Recent events, however, indicate that the function will be a wedding, not a funeral.

The duplex process is rapidly gaining favour, and details are being worked out in different ways by different metallurgists. The principle involved in the union is similar to that which contributed to the happiness of the Spratt family, of nursery fame, since the acid Bessemer converter cannot devour phosphorus, whilst the open hearth furnace finds the removal of carbon and silicon tedious. The duplex process, therefore, involves the desiliconisation and partial decarburisation of blast furnace metal in an acid-lined converter and the subsequent removal of phosphorus in a basic-lined open hearth furnace. It does not follow that the plant, although composed of two distinct elements, involves a greater capital outlay in proportion to tonnage output than does the more expensive of these elements when used singly. By giving the open hearth furnace only the work to do which it can perform to greatest advantage, an increase in the number of heats results. The converter also can operate on shorter cycles and can be of greater capacity.

The Baneful Effects of too much Theory.

The following application made to a leading firm of civil engineers in answer to an advertisement for a junior assistant civil engineer we have considered worthy of reproduction in that it illustrates a bad case of an overdose both of theoretical knowledge and self-confidence.

"Dear Sir,—I beg to offer my services for appointment of junior assistant civil engineer. I will merely give you here an outline of my qualifications, and I trust that if I can make you interested you may grant me a personal interview, which I should greatly appreciate. I am a *civil engineer* with some particular claim to the title, in that I can use, to good purpose, my hands and my wits. I have had about four years technical training in science, including four sessions of engineering at the Technical College of —— and the rest privately. At the present time I am studying for degrees of London University in law and science (B.Sc. and LL.B.) and have lately sat in competition for Whitworth Scholarship, which I hope to carry off. I attach competitive subjects which I took. [Only 16!—ED.]

"I have had a practical experience of three years with —— in structural steelwork, river and dock walls, and retaining walls, &c., mechanical, hydraulic and electrical machinery. In the appointment of Lecturer in Civil Engineering at —— University, in May, the Senate placed me second on the list (and that's at 22!) of selected candidates.

"I have been 22 years in the world and during that time my observations have not been in vain and, sir, I honestly believe I'd make you a good assistant if you gave me plenty of *responsible* work! I've got *some* originality, and am deeply-read in engineering practice of our own engineers and our neighbours, especially Americans. Indeed, I say (with as little egotism as I can!), I am as little afraid of designing the greatest bridge as I d be of designing a sewer of clay pipes. Of course, the ultimate result would depend upon the energy put in; but the *will's* there. To let you see that I'm sincere, I make the offer to give you a free trial of my services for any time you think advisable, and then perhaps salary may be discussed.

"The following are subjects I can tackle:—*Bridge* work of all classes, including masonry; *railway* work from foundry to track; *mechanical* and *electrical* work; *harbour*, *river* and *dock* works (such as piers, groynes, reclamation works, &c.); *waterworks* and *municipal* engineering; *mining* (all classes); *surveying* for Parliamentary plans, &c. (hydrographical, astronomical and geodetic); and of course the preliminary work connected therewith. I trust what I have said may interest you and that you will let me have permission of visiting you. Yours truly, ——.

"P.S.—My general education I have not stated, but I think you will understand the rank of it when I tell you it is of the kind after Sir Oliver Lodge's heart! *i.e.*, dead languages, two modern languages, and good taste in literature. I received it privately (what wonder!).

"P.P.S.—I expect to be a Fellow of Physical Society (London) shortly."

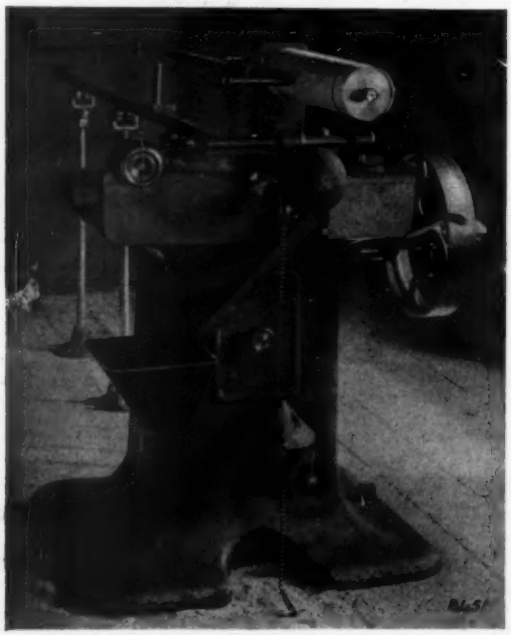
Testing a Centrifugal Fan.—Readers of this interesting series of articles by Mr. C. L. Browne are informed that the next instalment, together with the matter omitted in the December number, will be published in the next issue.

Machinery, Appliances and Processes.

The Editor invites advance particulars, drawings, blue prints, photographs, and any data that will enable him to publish an adequate description in these columns of any new work, machinery, or installation, possessing special features of interest. The cost of publication and engraving is borne by us, and no compensation is expected. In the endeavour to produce a really high-class and technically valuable machinery section the Editor seeks the co-operation of engineers and manufacturers.

File Testing and Indicating Machine.

Among the new and improved machines to which our attention has been recently drawn is one which is attracting a good deal of notice, namely, a machine for testing files. Its introduction has rendered it possible for file makers to employ high class modern tool steel and has led to an enquiry into the whole subject of file cutting with special reference to the most efficient angles and shapes of file teeth. The result has been a remarkable improvement in the cutting properties of files, that is, an increase in the amount of metal which can be filed away in a given number of strokes under standard conditions.

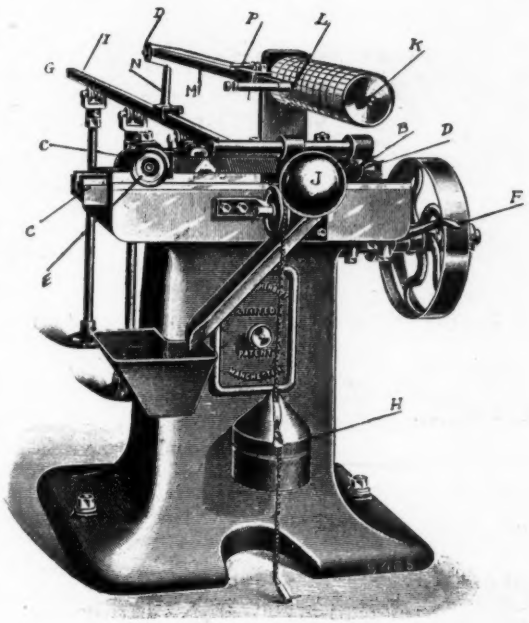


FILE TESTING AND INDICATING MACHINE.

Referring to the lettered illustration, the file to be tested *a*, is held between two headstocks b,b^1 on a reciprocating table *c*. Headstock *b* is provided with a nut and a hollow squared screw *d*, for holding the tang of the file and exerting end pressure: headstock b^1 has a slide and a handwheel whereby the file may be adjusted with its working face parallel to its direction of motion. The reciprocating motion of the table is obtained from the pulley and main shaft through a pair of bevel gears, driving a T slotted crank disc. A crank pin, whose position in the T slot can be varied according to the stroke required, carries a slide block of rectangular form, which slides between two vertical bearing surfaces in an extension of the table *c*, and serves to drive the latter to and fro. The driving mechanism is inside the box frame of the machine and entirely protected from the filings. The machine is started and stopped by a clutch operated by a handle *f*.

The test bar *g* is supported in a horizontal position on grooved rollers, and is pressed against the file by a weight *h*, and a chain

passing over a pulley and under the bar, to the far end of which it is attached by a hook. The support rollers are grooved to accommodate the chain. The bar is drawn back out of contact with the file during the back stroke of the latter by means of a clutch lever, having two hardened jaws loosely embracing the test bar. At the commencement of the back stroke, motion is communicated from a cam on the crank shaft to the outward end of the clutch lever, causing it to tilt and grip the test bar after the manner of a spanner. A slight continuation of the same motion causes it to draw back the test bar, which is again released at the commencement of the forward cutting stroke. A spherical weight *j*, with a screwed stem, is supported by the headstock *b*, and of course reciprocated with the file. The end of the stem rests against the back of the file, and the inertia of the weight prevents the chattering and jarring of the file which would otherwise take place.



FILE TESTING AND INDICATING MACHINE.

The drum *k*, round which is wrapped the diagram sheet of squared paper, is driven from a cam on the crank shaft through a pawl and ratchet wheel and a train of reducing gears, so as to make one revolution to 120,000 strokes of the file. A pencil *l*, is pressed against the paper by a light spring and is carried on a bar *m*, capable of sliding longitudinally in a fixed bearing. A block *n*, is attached to the test bar, and a fusee chain is attached to this block, and passing over a pulley *o*, on the pencil bar, is held by a fixed terminal *p*. It is evident that as the test bar is filed away it is moved forward by the weight *h*, and a given movement of the test bar causes the pencil to move forward by half that amount. The diagram sheet is graduated in half inches, each of which represents one inch filed off the test bar. The circumference of the drum is 12 in., and as it revolves under the pencil each inch represents 10,000 strokes of the file. At the commencement of a test the pencil is set to zero, and as the drum revolves and the test bar is filed away, a curve is drawn by the compound motion of the drum and pencil. This curve is a complete picture of the life of the file from the commencement of the test until the file is worn out and ceases to cut, the slope of the curve indicating the sharpness or rate of cutting, while the ordinates and abscissae give respectively the total amount of work done by the file and the number of strokes required to do this work and to wear the file out.

The diagrams, Fig. 1. are exact reproductions, to a reduced scale, of curves drawn by the Indicating machine, from four bastard files by well-known makers.

Vertical distances represent the number of inches filed from a standard test bar of annealed cast iron, planed to a section of 1 in. by 1 in.

Curve 1 is from a file of good average quality. It cut quickly but was soon worn out, showing sharp teeth but poor steel. Curve 2 is from one of the new files of modern high-class steel, with correctly formed teeth, which have been introduced since the advent of the file testing machine. Curves 3 and 3a are from the two sides of another file. Durability was fairly good but rate of cutting slow, showing good steel but bad teeth. Curve 4 is from a bad file.

It will be seen that File No. 2 cut five times as fast when new, lasted 16 times as

long, and did 46 times as much work as File No. 4.

Fig. 2 is from a file of fine quality steel and carefully cut.

The nominal rate measures the sharpness of the file when new, irrespective of the quality of steel or temper. It is given by the tangent 'A' cutting the line of 10,000 strokes at 3·8 in. (nominal rate 3·8 in. per 10,000 strokes).

The mean rate is given by line 'B,' approximating to the general slope of the curve. It cuts the 10,000 line at 3·0 in. (mean rate 3·0 in. per 10,000 strokes). The machine is made by E. G. Herbert, Ltd., of Manchester.

Another interesting machine by the same firm is a friction cutting machine, also illustrated. Its chief feature is the disc which is of moderately hard steel, the edge having hollows ground in it at intervals so as to leave a series of blunt projections. The disc is run at a very high speed and the projections or teeth strike about half a million blows per minute on the work. The point of contact is instantly raised to a white heat, in which condition it is of course perfectly soft. The heating is entirely local, and the disc remains quite cold, and is not affected by cutting even such materials as hardened steel.

Large Morse Chain Drives.

The Westinghouse Brake Company, King's Cross, London, inform us that they have recently executed an order for what is probably the biggest chain power transmission yet attempted, that is to say, three Morse silent high-speed rocker-joint drives complete, each to transmit 500 h.p. These drives were ordered by an engine works in Russia, Government of Moscow, which already had a 280 h.p. Morse drive in satisfactory operation.

The accompanying illustration gives a good idea of the appearance of these large drives of which the following are further particulars: diameter of wheels 37·78 in.; face width 22 in.; chain 2 in. pitch, 10 in. wide. Two chains run side by side over one set of wheels at a speed of 1,480 ft. per minute.

New Portable Rivet Furnace.

The illustration on page 134 refers to a new type of portable furnace primarily intended for heating rivets, although

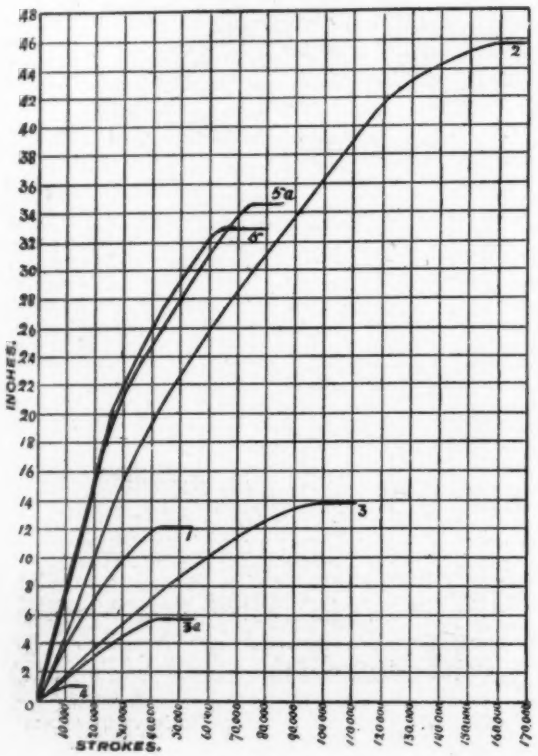


FIG. 1.

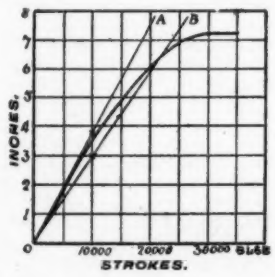


FIG. 2.

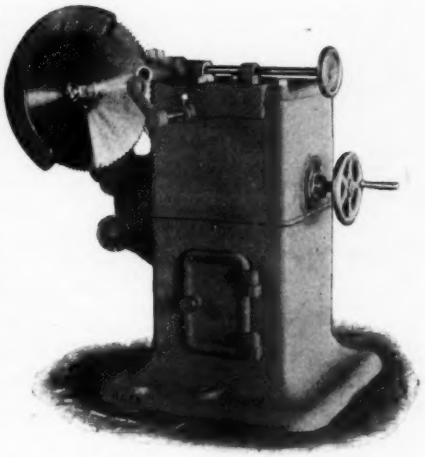
CURVES DRAWN BY THE FILE TESTING AND INDICATING MACHINE.

it may be employed for other metal articles. It has been introduced by Horace P. Marshall & Co., 6 and 7, Cross Fountaine Street, Leeds, who put forward on its behalf several important claims, chief among which is that the fuel consumption is low for the relative output of rivets, and the substantial manner of its construction. The latter feature will be apparent from the illustration and, it may be added, that 12 lb. plates are employed, joined at the corners with heavy angle irons and closely spaced rivets. The lining consists of special fire-bricks, which are interlocked and set in ganister. The furnace proper consists of the central heating chamber, having a heavy cast-iron door at the front. On each side of the heating chamber is a fire-box carrying a grate of ordinary form, each grate having an ash pit below it, with a cleaning door at the front. At the top of each fire-box is a circular fire-door, closed by a plate steel cover. A perforated pipe runs the entire length of the fire-bars in each ash pit, the pipe being provided with a plug at its rear end, so that it may be readily blown out.

The fire-boxes are separated from the heating chamber by a wall consisting of a steel plate, protected on either side by heavy fire-brick linings. In these walls are suitably arranged openings connecting the fire-boxes with the heating chamber. Extending beneath and up the back of the heating chamber is an air space, which effectively heats the incoming air before delivery to the heating chamber containing the rivets. The rear wall of the heating chamber has in it suitably arranged perforations leading from the above-mentioned air space. In front of this air space and below the main heating chamber are two dampers for regulating the amount of cold air which is admitted.

At the top of the heating chamber, near the front, is a substantial chimney controlled by a damper. Underneath the front door is a shelf, on to which the hot rivets may be drawn from the heating chamber as required.

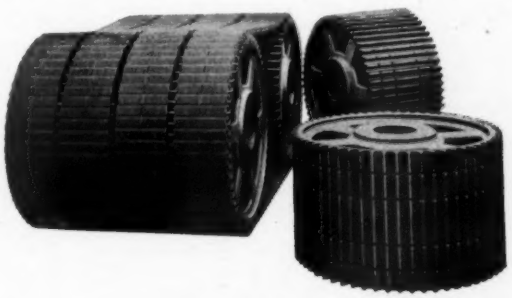
The blast apparatus for high pressure air consists of two nozzles carrying the air and projecting into bell-mouthed induction pipes, attached to the perforated blast pipes above described. These nozzles are controlled by suitable valves and joined across the front by means of gas pipe and fittings as shown. To the middle of this pipe is attached the hose carrying the high-pressure air supply. Where low-pressure blast is used, the nozzles are dispensed with and ordinary pipe connections made. The entire cover of the furnace is bolted on so as to be readily removable for the purpose of inspection and renewal of the fire-brick lining. As will be seen the furnace is mounted on wheels so as to make it readily portable.



FRICTION SAWING MACHINE.

The operation of the furnace is as follows: After starting the fire in both fire-boxes the blast is turned on and so regulated that no loss of efficiency is occasioned by excessive draught up the chimney. A quantity of rivets from ten to one hundred and fifty, as desired, is placed in the heating chamber and the door closed.

The products of combustion from the fires enter the heating chamber through the



LARGE MORSE CHAIN DRIVE.

PORTABLE RIVET FURNACE.

openings in the side walls, while cold air is drawn through the dampers at the front into the air space beneath the heating chamber, up the space at the back, and into the heating chamber through the perforations. In its course this air is heated to a high temperature, and on entering the heating chamber it meets the burning gases from the fire-boxes. Combustion is thereby completed, resulting in intense heat at the point where it is most needed. The burning gases completely envelope the rivets placed on the floor of the heating chamber.

The combustion is so nearly complete that once the furnace becomes thoroughly hot, and the blast is properly regulated, it is stated that no smoke will escape from the chimney, even when coal is used. For this reason it is claimed that the furnace may be used indoors without the necessity of connecting the chimney with the outer air. One boy readily attends to the entire operation of the furnace.

Either coke or coal may be used, but the former is preferable, since it is cleaner and cheaper.

The air blast may be the ordinary low-pressure smith-shop blast, or blast induced by a jet of high-pressure air by means of the device fitted to the furnace. Eight holes are provided, ·03 in. diameter, through which the high-pressure air is forced to produce the draught, so it will be seen that a very limited amount only is required. This air under pressure may be taken from the ordinary pneumatic distribution pipes.

The furnace is made in three sizes, No. 2 being the one most generally useful. This will accommodate 150 $\frac{3}{4}$-in. rivets at one time and has a heating capacity varying from 2,000 to 3,000 $\frac{3}{4}$-in. rivets per day, according to whether a high heat is required, as when closing by pneumatic hammers, or a lower temperature, such as will suffice for closing by hydraulic or other compression machines. Rivets are heated in from four to five minutes, and the fuel consumption of the No. 2 furnace is given as two cwt. of coke per day of nine hours when working up to its full capacity.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

The Erection of the Anchor Arms of the Blackwell's Island Bridge. *Engineering Record, 21st December*, 1907.

Retaining Walls on the Delaware, Lackawanna and Western Railroad at Buffalo. *Engineering Record, 21st December*, 1907.

Billeck Sluice Gates. *Engineer, 27th December*, 1907.

The Teltow Canal. *Engineer, 27th December*, 1907.

Reinforced Concrete Sea Defences, I.—A Dutch Example. By H. Huisman. *Concrete and Constructional Engineering, January*, 1908.

Erection of the Manhattan Approach of the Blackwell's Island Bridge. *Engineering Record, 28th December*, 1907.

The Engineering Features of the Proposed Henry Hudson Memorial Bridge. *Engineering Record, 28th December*, 1907.

A series of Failure Tests of Full-Size Compression Members made for the Pennsylvania Lines West of Pittsburg. *Engineering News, 26th December*, 1907.

Ferro-Concrete Viaduct; Richmond and Chesapeake Bay Railway, Virginia. *Engineering, 27th December*, 1907.

Notes on the Erection of Bridges, VIII. *Railway Engineer, January*, 1908.

Modern Development of British Fishery Harbours, VIII. By H. C. M. Austen. *Engineering, 20th December*, 1907.

Off-Shore Floating Dock for Fishing Vessels at Aberdeen Harbour. *Engineering, 20th December*, 1907.

Strength of Rings. *Engineer, 20th December*, 1907.

The New System of Waterways in Prussia. *Times Engineering Supplement, 1st January*, 1908.

The Queen's Approach to the Blackwell's Island Bridge, New York. *Engineering Record, 7th December*, 1907.

Schemes Showing the Possibilities of St. John N.B., as a great Port, and how the Interior of New Brunswick can be opened up to Ocean Traffic. By J. S. Armstrong. *Proceedings Canadian Society Civil Engineers, December*, 1907.

Keyham Dockyard Extension. By Sir Whately Eliot. *Transactions Institution Civil Engineers, 17th December*, 1907.

New Bridges over the Nile at Cairo. *Engineering, 10th January*, 1908.

The Design of Struts. By W. E. Lilly. *Engineering, 10th January*, 1908.

Building.

The Design of Power Plant Chimneys. *Engineering Record, 21st December*, 1907.

Reinforced Concrete Construction in the Rebuilding of San Francisco. *Concrete and Constructional Engineering, January*, 1908.

Erecting Machinery Foundations. By J. A. Pratt. *Machinery, December*, 1907.

The Design of 75ft. Reinforced-Concrete Girders for the Mammoth Garage, White Plains, New York. By C. E. Tirrell. *Engineering News, 12th December*, 1907.

Two New Record-Breaking Office Buildings in New York City. *Engineering News, 5th December*, 1907.

The Construction and Repair Division of the City of Chicago. By William D. Barker, *Engineering News, 5th December*, 1907.

Heating and Ventilation.

Ventilation and Warming of Workshops. By D. M. Nesbit. *Transactions Manchester Association Engineers, 14th December*, 1907.

Materials and Measurements.

Three-Scale Logarithmic Computing Paper for Solving Formulas. *Engineering News, 19th December*, 1907.

The Pitometer. By Ed. S. Cole, *Journal Franklin Institute, December*, 1907.

Accuracy of Slide Rule Computations. *Engineering Record, 21st December*, 1907.

Reinforced Concrete Systems in Great Britain. *Concrete and Constructional Engineering, January*, 1908.

Tests with Reinforced Concrete Beams and Columns. By C. F. Marsh. *Concrete and Constructional Engineering, January*, 1908.

Hand Bending Tests. By Captain H. Riall Sankey, R.E. *Engineering*, 20*th* and 27*th December*, 1907.

Boilers, Furnaces, and Fuel.

Value of Separators. Why necessary for the Economical Operation of a Steam Plant. By T. E. O'Donnell. *Engineer, Chicago*, 16*th December*, 1907.

The Specific Heat of Superheated Steam. By Prof. C. C. Thomas, *Proceedings American Society Mechanical Engineers, December*, 1907.

A Tubeless Semi-Flash Boiler. *Marine Engineer and Naval Architect, January*, 1908.

Steam Boilers (*continued*). *Practical Engineer*, 10*th January*, 1908.

The Nature of True Boiler Efficiency. By W. T. Ray and Hy. Kreisinger. *Journal Western Society Engineers, October*, 1907.

The Present Status of the Producer-Gas Power Plant in the United States. *Journal Western Society Engineers, October*, 1907.

Engines and Motors.

Design of a 400 kw. Reaction Turbine. By H. F. Schmidt. *Engineer, Chicago*, 16*th December*, 1907.

Mechanical Points in Connection with Steam Turbines. *Engineer*, 27*th December*, 1907.

300 h.p. Section Gas Plant. *Engineer*, 27*th December*, 1907.

Third Report to the Gas Engine Research Committee. By Prof. F. W. Burstall. *Proceedings Institution Mechanical Engineers, January*, 1908.

The "Willans-Parsons" Steam-Turbine. *Engineering*, 3*rd January*, 1908.

Evolution of the Internal Combustion Engine. By Prof. S. A. Reeve. *Proceedings American Society Mechanical Engineers, December*, 1907.

Mechanical and Thermal Efficiency of a Petrol Engine. By L. G. E. Morse. *Transactions Institution Civil Engineers*, 20*th December*, 1907.

The Construction and Working of Large Gas Engines. By P. R. Allen. *Transactions Manchester Association Engineers*, 11*th January*, 1908.

Marine Steam Turbine Installation. *Mechanical World*, 10*th January*, 1908.

The Practical Proportioning of the Reaction Steam-Turbine. *Engineering*, 13*th December*, 1907.

Labyrinth Packings. *Engineering*, 10*th January*, 1908.

Hydraulics and Compressed Air.

Centrifugal Pumps for Fire Protection and Condenser Service. By E. F. Doty. *Engineer, Chicago*, 16*th December*, 1907.

Hydraulic Diaphragm Testing Machines. *Engineering*, 27*th December*, 1907.

Hydraulic Press Design. *Mechanical World*, 27*th December*, 1907.

Strength of Air Pressure Tanks. *Mechanical World*, 10*th January*, 1908.

Notes on Centrifugal Pumps, V. *Mechanical World*, 10*th January*, 1908.

Shop Equipment and Practice.

Reamers, V. By Erik Oberg. *Machinery, December*, 1907.

Tumbler Gear Design. By J. Edgar. *Machinery, December*, 1907.

Notes on Mill Power Plant, XVII. By C. J. Kavanagh. *Mechanical World*, 20*th December*, 1907.

Miscellaneous Mechanical Subjects.

Design of Light Structural Jib Cranes. By W. H. Butz. *Machinery, December*, 1907.

The Mechanical Engineer and the Function of the Engineering Society. By Prof. F. R. Hutton. *Proceedings American Society Mechanical Engineers, December*, 1907.

Design of Condensing Plant, XXVII. *Mechanical World*, 13*th December*, 1907.

Mild Steel Tank Practice. *Mechanical World*, 20*th December*, 1907.

Ball and Roller Bearings in Practical Operation. By S. S. Eveland and Discussion. *Proceedings Engineers' Club, Philadelphia, October*, 1907.

Locomotive and Railway Engineering.

The Design of Wayside Stations for Single Line Railways. By G. R. Dawson. *Engineering Record*, 28*th December*, 1907.

The Smoke Consuming Question Forty-Eight Years Ago. By C. H. Caruthers. *Railway Gazette*, 27*th December*, 1907.

The Puy de Dome Adhesion Railway. *Engineer*, 27*th December*, 1907.

A New Railway Signalling System. *Electrical Review*, 27*th December*, 1907.

The Heinle Rail Section. *Railway and Engineering Review*, 21*st December*, 1907.

The Locomotive from Cleaning to Driving, XII. By Jno. Williams and Jas. T. Hodson. *Railway Engineer, January*, 1908.

Siemens Bros', "All-Electric" Signalling and Interlocking at Snow Hill, Birmingham, Great Western Railway. *Railway Engineer, January*, 1908.

Steel Passenger Equipment. By Chas. E. Barba and Marvin Singer. *American Engineer and Railroad Journal, December*, 1907.

Increase in Weight of Locomotives. *Railway and Engineering Review*, 28*th December*, 1907.

Co-efficients of Friction between Wheels and Rails. By G. L. Fowler. *Railway Gazette*, 10*th January*, 1908.

The Dearne Valley Railway (continued). *Railway Gazette*, 10*th January*, 1908.

Level Crossing Gates worked electrically by the Passage of the Train. By S. Horzog. *Le Genie Civil*, 21*st December*, 1907.

Motor Engineering.

The Progress of Automobilism in 1907. The Salon of the Automobile, the Cycle and of Sports. By F. Drouin. *Le Genie Civil*, 23*rd December*, 1907.

Variable Gears for Motor Bicycles. *Automobile Club Journal*, 26*th December*, 1907.

"Humphris" System of Gear-Wheel Design. *Automotor Journal*, 21*st* and 28*th December*, 1907.

The Morris Steam Car. *Automotor Journal*, 28*th December*, 1907.

The Principles of Carburetting, as Determined by Exhaust Gas Analysis. *Autocar*, 14*th*, 21*st*, and 28*th December*, 1907.

The Wade and Jones Ignition Set, with Autoloc Control Lever. *The Autocar*, 28*th December*, 1907.

Gears and Gearing. By F. Humphris. *Automobile Club Journal*, 19*th December*, 1907.

An Electrical Brake Tester. *Autocar*, 21*st December*, 1907.

The Principles of Carburetting as Determined by Exhaust Gas Analysis. By Dugald Clerk. *Automotor Journal*, 21*st December*, 1907.

The "Jackson" Epicyclic Gear for Cars, Cabs, Vans, and 'Buses. *Automotor Journal*, 14*th* and 21*st December*, 1907.

Petrol Electric Motor Omnibuses. The "Hart-Durtnall" Polyphase Alternating Current System. *Electrical Engineer*, 3*rd January*, 1908.

Electric Lighting.

On Vacuum Tube Electric Lighting. By J. A. Fleming. *Illuminating Engineer, January*, 1908.

Street Lighting by Arc Lamps in the City of London. *Electrician*, 3*rd January*, 1908: *Electrical Engineering*, 12*th December*, 1907.

Electrical Generation and Transmission.

Torque Conditions for Alternate Current Motor. *Electrical Engineering*, 26*th December*, 1907.

The Theory of Alternate Current Transmission in Cables. By C. V. Drysdale. *Electrician*, 13*th*, 20*th*, and 27*th December*, 1907; 3*rd* and 10*th January*, 1908.

Long Island City Power-Station of the Pennsylvania Railroad Company, V. *Engineering*, 20*th December*, 1907.

Direct Current Motors—Their Action and Control, II. *Electrical World*, 7*th December*, 1907.

The Influence of the Rated Speed and Outputs on the Design of Continuous-Current Generators. By H. M. Hobart. *Electrical Review*, 20*th December*, 1907.

Cost of Electrical Power for Industrial Purposes. By J. F. C. Snell. *Transactions Institution Electrical Engineers, December*, 1907.

The Erection and Connecting up of Electric Motors (*continued*). *Practical Engineer*, 10*th January*, 1908.

Notes on the Development of Turbo-Generators. By Dr. Pohl. *Transactions Institution Electrical Engineers, January*, 1908.

Inductive Voltage Drop on Three-Phase Transmission, with the Conductors Lying in the Same Plane. By Alf. Still, A.M. Inst. C.E. *Electrical Engineer*, 10*th January*, 1908

Electric Traction.

Brembana Valley Single Phase Railway. *Electrician*, 27*th December*, 1907.

A New Suspension for the Contact Wires of Electric Railways Using Sliding Bows. By J. Meyer. *Transactions American Society of Civil Engineers, December*, 1907.

Overhead Construction for High-Tension Electric Traction or Transmission. By R. D. Coombs. *Transactions American Society of Civil Engineers, December*, 1907.

Overhead Construction on a Fifteen Cycle, Single Phase Railway in California. *Street Railway Journal*, 7*th December*, 1907.

Electrification of the Rochester Division of the Eric Railroad. *American Engineer and Railroad Journal, December*, 1907.

Electric Traction on Railways, VI. By P. Dawson, *Electrician*, 3*rd January*, 1908.

Rail Corrugation. By A. Forbes. *Tramway and Railway World, December*, 1907.

The "Vienna-Baden" Single Phase Railway. *Electrical Engineering*, 12*th December*, 1907.

Tangential Suspension of Trolley Wires. *Electrical Times*, 9*th January*, 1908; *Electrical Engineering*, 9*th January*, 1908.

The Use of Ball Bearings on Electric Motors, *Electrical Review*, 10*th January*, 1908.

Signals for Trolley Car Lines. *Tramway and Railway World, January*, 1908.

Bonding. By E. Goolding. *Tramway and Railway World, January*, 1908.

A 1,500 volt Continuous-Current Railway in the Misoxer Valley. *Electrical Engineering*, 9*th January*, 1908.

Miscellaneous Electrical Subjects.

Electrical Equipment at the Clausthal Mines. *Electrical Engineering*, 26*th December*, 1907.

Electric Cranes. By H. H. Broughton (*continued*). *Electrician*, 27*th December*, 1907.

A Directive System of Wireless Telegraphy. *Electrical World, New York*, 21*st December*, 1907.

Torque Analysis of Induction Motors. By A. R. Dennington. *Electrical World, New York* 21*st December*, 1907.

The Use of Electricity in the Manufacture of Armour Plates. *Electrical Review*, 27*th December*, 1907.

The Electrical Equipment of the "Burbacher-Hutte" Iron and Steel Works. *Electrical Engineering*, 2*nd January*, 1908.

Electrical Measuring Instruments, and Some of their Weaknesses. By Kenelm Edgecumbe. *Proceedings Association Engineers-in-Charge*, 8*th January*, 1908.

Characteristics of the Magnetite Arc. By G. M. Dyott. *Electrical World, New York*, 7*th December*, 1907.

The Heat Conductivity of Iron Stampings. By Thos. Morgan Barlow. *Transactions Institution Electrical Engineers, January*, 1908.

Coil Winding Machine. *Electrical Engineering*, 20*th December*, 1907.

The Leakage of Induction Motors. By Dr. R. Goldschmidt, *Electrician*, 20*th* and 27*th December*, 1907, 3*rd January*, 1908.

Construction and Operation of a Power Factor Indicator. *Western Electrician*, 28*th December*, 1907.

Direct Reading Galvanometer Scales. By J. Rymer-Jones, *Electrical Review*, 10*th January*, 1908.

Marine Engineering and Naval Architecture.

Floating Docks. By H. R. Jarvis. *Proceedings North-East Coast Institution Engineers and Shipbuilders*, 10*th January*, 1908.

Repairs to Machinery. By R. Elliott before Institute Marine Engineers. *The Steamship*, *January*, 1908.

New Egyptian Mail Turbine Steamship *Heliopolis*. *International Marine Engineering*, *January*, 1908.

The Heating and Ventilating of Ships. By Sydney F. Walker. *International Marine Engineering*, *January*, 1908.

The Cunard Steamship *Mauretania*. *International Marine Engineering*, *January*, 1908.

The Hamburg-American Steamer *Kronprinzessin Cecilie*. *International Marine Engineering*, *January*, 1908.

The Behaviour of a Ship's Structure under Stress. By W. R. G. Whiting. *Transactions North-East Coast Institution Engineers and Shipbuilders*, 21*st December*, 1907.

The Twin Screw Allan Liner "Corsican." *Engineering*, 10*th January*, 1908.

Streets and Pavements.

Water Supply.

Flow of Water in Open Conduits. By A. P. Merrill. *Engineering Record*, 28*th December*, 1907.

Sewage.

Engineering Economics and Works Management.

The Management, Organisation and Working Cost of a Public Service Motor House. By W. E. Hardy. *Automobile Club Journal*, 12*th December*, 1907.

Miscellaneous.

Nitric Acid from Air. By J. Moscicki. *Electrochemical and Metallurgical Industry*, *December*, 1907.

The Rolling of Thunder. By D. S. Carpenter. *Electrical World*, *New York*, 21*st December*, 1907.

Illumination—Its Distribution and Measurement. By A. P. Trotter. *Illuminating Engineer*, *January*, 1908.

The Present Status of Acetylene Lighting. By T. H. Leeds. *The Illuminating Engineer*, *January*, 1908.

The Production and Utilisation of Light. By C. V. Drysdale. *The Illuminating Engineer*, *January*, 1908.

Specific Heats of Nitrogen, Carbon Dioxide and Steam. *Engineering*, 3*rd January*, 1908.

Petrol-Air Gas. By Ed. Scott-Snell. *Gas World*. 4*th January*, 1908.

Dr. Ostwald's Process for the Production of Nitric Acid and Nitrate of Ammonia from Ammoniacal Liquor, as Applied to the Gas and Coke-Oven Industries. By F. D. Marshall. *Iron and Coal Trades Review*, 20*th December*, 1907.

A Radio-Active Gas. By Sir Wm. Ramsey. *Journal Society of Arts*, 13*th December*, 1907.

The Discovery of the Alkali Metals by Davy; the Bearing of the Discovery upon Industry. By Dr. F. Mollwo Perkin, before the Faraday Society, 17*th December*, 1907.

Cartridge Metal Rolling Mill. *Engineering*, 20*th December*, 1907.

The Electro-Thermic Production of Iron and Steel. By Jas. W. Richards. *Journal Franklin Institute*, *December*, 1907.

A Modern Quarry Plant. *The Engineer*, 13*th December*, 1907.

On a Deficiency in the Nomenclature of Mineral Deposits. By H. Louis. *Transactions Institution Mining and Metallurgy*, *December*, 1907.

The Assay of Telluride Ores. By G. T. Holloway and L. E. B. Pearse. *Transactions Institution Mining and Metallurgy*, *December*, 1907.

Rescue Apparatus for Use in Mines. By James Bain. *Transactions Mining Institute of Scotland*, *August*, 1907.

The Canadian Branch of the Royal Mint. *Times Engineering Supplement*, 8*th January*, 1908.

Pit Bottom Arches and General Arrangements for Modern Collieries. I. *Iron and Coal Trades Review*, 10*th January*, 1908.

Books Received.

The **"Mechanical World" Pocket Book and Diary** for 1908. Price, 6*d.* net: also the **Electrical Pocket Book** for 1908. Price, 6*d.* net. Manchester: Emmott & Co., Ltd., 65, King Street.

"Fascinating Egypt." London: The "African World," 34, Copthall Avenue, E.C. Price, 1*s.* net.

"Who's Who," 1908. Price, 10*s.* net.

"Who's Who" Year Book. Price, 1*s.* net.

Writers' and Artists' Year Book. Price, 1*s.* net. London: A. & C. Black, 4, Soho Square.

Iron and Steel, by J. H. Stansbie, B.Sc., F.I.C. The Westminster Series. London: Constable & Co., 10, Orange Street, 1907. Price, 6*s.* net.

The **Deinhardt-Schlomann Series** of Technical Dictionaries in six languages. German, French, English, Russian, Italian and Spanish. Vol. II. Electrical Engineering, including Telegraphy and Telephony, edited by Chas. Kingbrunner, A.M.I.E.E. With 4,000 illustrations. London: Constable & Co., Ltd. Price, 25*s.* net. 1908.

MANUFACTURERS' NOTES.

Drysdale & Co., Ltd., Glasgow, notify that in future all business communications should be addressed to Ferry Road, Yoker, Glasgow. The South Wales Power Co., having decided to extend its plant, has placed an order with the **British Westinghouse Electric and Manufacturing Co., Ltd.,** for one 3,000 k.w. turbo-generator, 1,500 revolutions per minute, and complete high vacuum surface-condensing plant fitted with the "Westinghouse-Leblanc" dry air pump.

The keen competition from the United States, Germany, &c., has forced our manufacturers to adopt new methods of contract in their workshops and mills. Greater accuracy of the detail of manufacture is the key-note to lesser cost of production or increased output. To obtain this the automatic time recorder has become almost a necessity, as by its use the employer obtains an independent and accurate printed record of the time worked by his employees as well as actual time spent on any process of manufacture. By this system the manufacturer is provided with reliable data for analysis, and can therefore put his finger on heretofore undiscovered excessive cost or leakages of time between jobs. The **International Time Recording Co.'s** latest improved time recorder is of the "Rochester" type and automatically prints the regular time of arrival of employees in *blue*, and the "late comers" in *red*. This improvement should popularise an already popular system of control of time and costs.

The Battersea Borough Council have accepted the tender of the **British Fuel Economiser and Smoke Preventer Co.,** of 9, Bedford Row, W.C., for smoke preventing and fuel economising apparatus for use on the boilers at the Latchmere Road Baths.

TRADE LITERATURE.

Alfred Herbert, Ltd., Coventry. Illustrated pamphlet descriptive of the No. 1 universal cutter grinder; also J section of catalogue dealing fully with the firm's hexagon turret lathes. **Siemens Brothers & Co.,** Westminster. Catalogue No. 501 of electrical resistance pyrometers, testing sets and accessories. **Veritys, Ltd.,** 31, King Street, W.C. Sectional catalogue of electric lighting accessories, including those specially designed for colonial and tropical use, where high insulation is essential. **"Phos" Co.,** Balls Pond Road. Catalogue of acetylene generators and plant. **Bergtheil & Young,** 12 Camomile Street, E.C. Pamphlet, No. 40, on the "Bandy" electrically-driven punkah. **Crosby Steam Gauge and Valve Co.,** 147, Queen Victoria Street, E.C. Pamphlet entitled "Hints on Indicating Gas and Oil Engines." With the increase in the size of internal combustion engines, and the higher pressures used, there is room for information as to the use of the gas engine indicator. The hints given are based on experience over a number of years, and not only are instructions given how to fit up and use the indicator, but suggestions are put forward as to how some of the various causes which tend to produce errors in the diagrams may be eliminated. The firm are distributing the booklet free to all who are interested. **Crompton & Co., Ltd.,** Salisbury House, London Wall, E.C. Catalogue P. 28 of the "Crompton-Blondel" system of flame arc lighting. **The Cruse Controllable Superheater Co.,** 5, Blackfriars Street, Manchester. Booklet dealing with a new tubular heat accumulator superheater, by which to a certain extent a temperature governing effect is obtained. **The Empire Roller Bearings Co., Ltd.,** 15, Victoria Street, S.W. Revised list of "Empire" roller bearings. **Mountain & Gibson, Ltd.,** Bury. Pocket diary and catalogue for 1908. **Goodwin, Barsby & Co.,** Leicester. Booklet dealing with the "Acme" fuel economiser and smoke consumer for steam boilers. **C. Whittaker & Co. (1900), Ltd.,** Accrington. New illustrated catalogue of clay working machinery, including grinding mills, presses, semi-plastic brick machinery, screens, elevators, pugs and cutting-tables. **Siemens-Schuckert Werke,** Berlin. Leaflets, A.B. 11, Hornerblitzablister für elektrische Strassenbahnem; 12, Selbsttätige Luftdruckbemse für Strassenbahen; 13, Bahnmotoren mit Wendepolen. **Société Anonyme Westinghouse,** 2, Norfolk Street, W.C. Circular descriptive of pumps and condensers on the "Westinghouse-Leblane" system. **Geo. Robson & Co.,** Sheffield. Pamphlet describing a portable electric grinder and catalogue, No. 16, of elevators and conveyors. **Industrial Improvements Co.,** 2, Jewry Street, E.C. Leaflets on a "Water Seal" automatic discharge valve or steam trap, and on the drainage of steam ship whistles. **W. N. Brunton & Son,** Musselburgh. Booklet descriptive of "Kilindo" non-rotating wire rope. **J. Cowens & Co.,** Hamburg Chambers, Newcastle-on-Tyne. Circular dealing with an "Ideal" cutting compound for use in place of lard oil or soap-and-water in the operations of forming, screwing, turning and drilling.

WORKSHOP PRACTICE PRIZE COMPETITION.

AWARD OF PRIZES.

The four prizes offered in connection with the fourth competition which closed on January 15th, for the best short article on an emergency device or rig carried out by machine tool operators, foundrymen, fitters or pattern makers, have been awarded as follows:

PRIZE OF £4.

MR. FRANK BALL,
Westoe, South Shields.

PRIZE OF £1.

MR. CHAS. J. FOZELL,
Ladywood, Birmingham.

PRIZE OF £1.

MR. SYDNEY LAWRENCE,
Salford, Manchester.

PRIZE OF £1.

MR. WILLIAM FINES,
St. Pauls, Worcester.

The prize articles will be printed in the next issue. Meantime we again offer four prizes—one of £4 and three of £1—for the best short article describing and illustrating any emergency device or any job which has taxed the ingenuity of the machinist, pattern maker, fitter, smith, or foundry operator.

The awards will be announced in the April number.

INSTRUCTIONS AND CONDITIONS.

Articles must be written on one side of the paper only, and be signed by the competitor.

Drawings and sketches must be on separate sheets of paper.

A short biographical sketch of the competitor's technical experience must accompany the article.

The right is reserved of publishing the prize articles, and also any of the others sent in; but in the case of the latter, payment will be made for the same at our usual scale rates.

The Editor's decision in all matters connected with the competitions shall be final, and binding on all the competitors.

All articles should be addressed to the Editor of THE ENGINEERING REVIEW, 104, High Holborn, London, W.C., and marked on the outside, "Competition," and the same must be received not later than March 15th.

NOTE.—Do not forget to send your address.